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ERRATA

In the paper "Occurrence of *Nonionella cockfieldensis* at Claiborne, Alabama," by J. B. Garrett, Jr., *Journal of Paleontology*, vol. 10, no. 8, December, 1936, p. 785, the subtitle to the faunal list should read "Microfauna from Beds 11 and 12 at Claiborne Bluff" instead of "Microfauna from Beds 10 and 11 at Claiborne Bluff."

JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 4, PP. 309–317, PL. 40, 2 TEXT FIGS., JULY, 1938

THE HACKBERRY ASSEMBLAGE— AN INTERESTING FORAMINIFERAL FAUNA OF POST-VICKSBURG AGE FROM DEEP WELLS IN THE GULF COAST

J. B. GARRETT

ABSTRACT

Attention is called to the presence in Gulf Coast subsurface strata of a distinctive foraminiferal fauna overlying Vicksburg, Oligocene, beds. Species that are common in the assemblage are recorded and stratigraphic position of the fauna is indicated by means of a check list. The name "Hackberry" is suggested to designate this fauna in the Gulf Coast. The approximate distribution of the fauna is indicated by a paleogeographic map. Four new species are described from the fauna. Mention is made of the similarity of the assemblage to that of the Alazan, or Huasteca, beds of Mexico, and to a fauna from Cuba.

It is generally recognized that Tertiary strata in the Gulf Coast tend to become more marine as the axis of the Gulf Coast geosyncline is approached. Logically, therefore, the approximately 2,000 feet of sandy unfossiliferous beds lying below the zone of *Marginulina mexicana* var. *vaginata* and above the Vicksburg formation should be represented by marine strata down-dip. Deep wells have proved this to be the case. A particularly interesting foraminiferal fauna appears roughly half-way between the top of the *Marginulina mexicana* var. *vaginata* zone and the top of the Vicksburg and continues downward for several hundred feet. This fauna differs greatly from assemblages ordinarily encountered in the Gulf Coast Tertiary section, and has a remarkably large number of species in common with the Alazan fauna described by Cushman (1926, 1927) and by Nuttall (1932) from the Tampico region, Mexico. The fauna also has a large number of species in common with a fauna from Finca Adelina, Matanzas Province, Cuba, described by Palmer and Bermudez (1936).

For some time, I have used "Alazan assemblage" to designate this fauna in economic work, largely because it seemed the most convenient name, and no single fossil appeared to be common and persistent enough for a zone marker. Recently, however, Muir (1936) has proposed that the name "Huasteca" be substituted for "Alazan," because of the poor character of the Alazan locality (see pp. 120–131). I believe it expedient, therefore, to propose that "Hackberry assemblage" be used to designate this fauna in the Gulf Coast, since the fauna is especially well developed in the Hackberry field, Cameron Parish, La. I have had opportunity to make a detailed study of the fauna from wells in the field. Excellent well-preserved specimens can be obtained from the sticky shale which is characteristic of the horizon. A list of common species from the assemblage in the Hackberry field follows.

FORAMINIFERA FROM HACKBERRY FIELD, CAMERON PARISH, LOUISIANA

Ammodiscus incertus (d'Orbigny)
Trochamminoides sp.
Ammobaculites nummus Garrett, n. sp.
Cyclammina sp.
Spiroplectammina sp.
Ammospirata mexicana (Cushman)
Textularia cf. *dentimarginata* Nuttall
Vulvulina spinosa Cushman
Verneuilina mexicana Nuttall
Gaudryina asiphonia (Andreae)
Gaudryina cylindrica Nuttall
Gaudryina cf. *jacksonensis* Cushman
Clavulina alazanensis Nuttall
Clavulina cyclostomata (Galloway andMorrey)
Quinqueloculina sp.—small
Sigmoilina tenuis (Czjzek)
Triloculina sp.—small

Cristellaria budensis (Hantken)
Cristellaria calcar (Linne)
Cristellaria formosa Cushman
Cristellaria kemperi Hanna
Cristellaria subpapillosa Nuttall
Marginulina pseudohirsuta Nuttall
Marginulina subbullata Hantken
Marginulina sublituus (Nuttall)
Marginulina texana Garrett and Ellis
Dentalina multilineata Bornemann
Dentalina spp.
Nodosaria acuminata Hantken
Nodosaria longiscata d'Orbigny
Nodosaria raphanistrum (Linne)
Pseudoglandulina comatula (Cushman)
Pseudoglandulina conica (Neugeboren)
Saracenaria sp.
Palmula semiornata (Nuttall)
Guttulina irregularis (d'Orbigny)
Glandulina sp.
Sigmomorphina sp.
Nonion lunatum Garrett, n. sp.
Nonion pompiloides (Fichtel and Moll)
Plectofrondicularia mexicana (Cushman)
Plectofrondicularia vaughani Cushman
Buliminella subfusiformis Cushman
Bulimina inflata Seguenza
Bulimina ovata d'Orbigny
Bulimina pupoides d'Orbigny
Bulimina sculptilis Cushman
Entosolenia sp.
Virgulina sp.
Bolivina alazanensis Cushman
Bolivina mexicana Cushman
Bolivina mexicana Cushman var. *aliformis* Cushman
Bolivina tectiformis Cushman
Bolivina tongi Cushman
Rectobolivina mexicana (Cushman)
Bifarina vicksburgensis (Cushman)
Uvigerina alazanensis Nuttall
Uvigerina auberiana d'Orbigny
Uvigerina canariensis d'Orbigny var.
Uvigerina carapitana Hedberg
Uvigerina cubana Palmer and Bermudez var.
Uvigerina mexicana Nuttall
Uvigerina stephensoni Garrett, n. sp.
Siphogenerina cf. *lamellata* Cushman
Nodosarella subnodosa (Guppy)
Ellipsonodosaria verneuili (d'Orbigny)
Ellipsonodosaria spp.
Discorbis sp.
Valvulineria nuttalli Palmer and Bermudez
Gyroidina cf. *depressa* (Alth)
Gyroidina scalata Garrett, n. sp.
Gyroidina soldanii d'Orbigny var.
Eponides crebbsi Hedberg
Eponides umbonata Reuss
Siphonina tenuicarinata Cushman
Amphistegina sp.
Ceratobulimina alazanensis Cushman and Harris
Pulvinulinella culter (Parker and Jones) var.
Cassidulina spp.
Ehrenbergina sp.
Allomorphina sp.
Chilostomella oolina Schwager
Chilostomelloides oviformis (Sherborn and Chapman)
Pullenia spp.
Sphaeroidina variabilis Reuss
Globigerina venezuelana Hedberg
Globigerina spp.
Orbulina universa d'Orbigny
Anomalina flintii Cushman var. *adelinensis* Palmer and Bermudez
Anomalina mecatepecensis Nuttall
Planulina marialana Hadley
Planulina mexicana Cushman
Cibicides americanus (Cushman) var.
Cibicides mexicanus Nuttall
Cibicides perlucidus Nuttall
Cibicides ungerianus d'Orbigny

This assemblage is characteristic as a whole, but certain species are especially common and useful. Some of these are *Marginulina texana*, *Bolivina mexicana*, *B. tectiformis*, *B. alazanensis*, *B. tongi*, *Gyroidina scalata*, n. sp., *Eponides umbonata*, *Rectobolivina mexicana*, *Nonion lunatum*, n. sp., and *Uvigerina stephensoni*, n. sp. As might be expected from its stratigraphic position, the assemblage carries species common to the *Marginulina mexicana* var. *vaginata* zone and to the Vicksburg. Species occurring in the former are mostly undescribed, but include *Bifarina vicksburgensis*, *Nonion pizarrense*, *Eponides* cf. *antillarum*, and *Amphistegina* sp. An interesting and useful comparison can be made on the one hand between *Bolivina perca*, n. sp., occurring in the *Heterostegina* and *Marginulina* zones, and on the other hand, *Bolivina mexicana* and *B. alazanensis*. Species common to the Vicksburg include *Bifarina vicksburgensis*, *Bolivina byramensis*, and *Bulimina sculptilis*.

Check list.—The accompanying check list (fig. 1) is based on an excellent series of cores from the lower portion of Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., and shows the relationship between the Hackberry assemblage and the Vicksburg fauna. The *Heterostegina* and *Marginulina* zones are not included in the check list, but the first *Heterostegina* sp. occurred at 6,216 feet and the first *Marginulina mexicana* var. *vaginata*

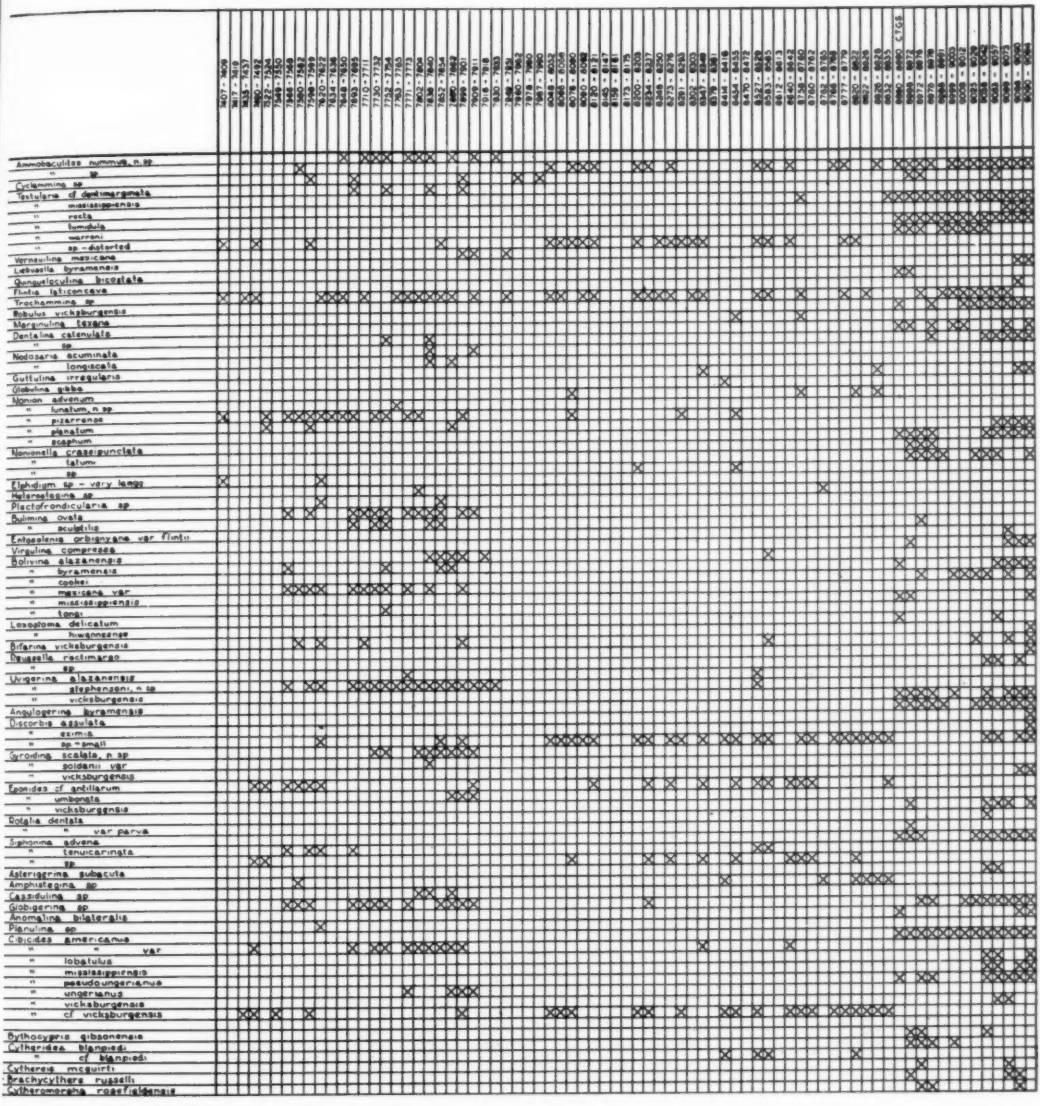

FIG. 1.—Check list of microfossils occurring in lower portion of Magnolia Petroleum Company no. 1 H. B. Funchess, Jr., Jefferson County, Tex.

at 6,520 feet. It will be seen that most of the species occurring in the Hackberry assemblage are not present in the Vicksburg, and that the Vicksburg fauna has a very large number of species found in the type Vicksburg at the outcrop. The well is located too near the old shore line for some species characteristic of the Hackberry assemblage to occur, but enough are present to identify the fauna.

Map.—The paleogeographic map (fig. 2) indicates the approximate shore line of *Marginulina texana*, one of the hardier species of the Hackberry assemblage.

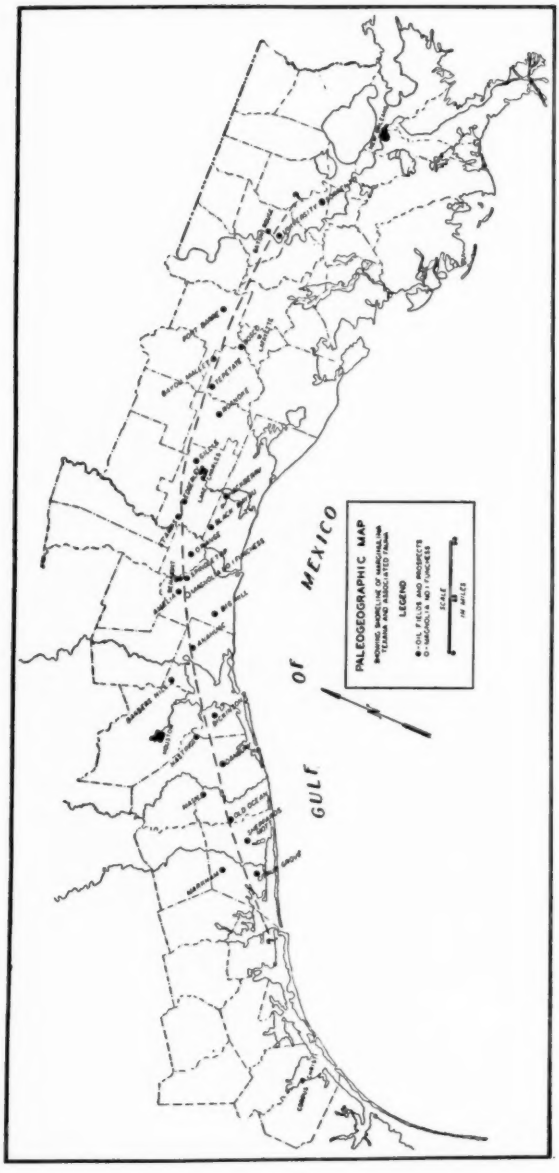

FIG. 2.—Paleogeographic map showing approximate shore line of *Marginulina texana* and associated fauna.

Needless to say, sufficient information was not available to locate accurately the position of the old shore line. In a down-dip direction the fauna improves rapidly in number of species and in number, size, and preservation of specimens. *Marginulina texana* is rare in the Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., but is ordinarily well developed near the highest occurrence of the Hackberry assemblage.

Literature.—Little has been written concerning the Hackberry assemblage in the Gulf Coast, aside from routine oil company reports. Howe (1936, p. 28), discussing the Sorrento dome, Ascension Parish, La., says:

> He (Craft), however, reports Vicksburg production from the Sorrento dome at depths around 4,300 feet. The writer has examined cores from this dome which contained a marine fauna unlike that of any members of the Vicksburg group which outcrop in Mississippi, but similar to that of the Meson formation of Mexico, a formation generally correlated with the Vicksburg. For that reason the Sorrento dome is indicated on the accompanying map, although the Vicksburg age of its production is obviously doubtful.

Howe has informed me that the cores mentioned contain a fauna which appears to be the Hackberry assemblage. This may prove to be true of other deep wells in the Gulf Coast reported to have reached Vicksburg. Hedberg (1937, p. 692) notes the resemblance of the Hackberry assemblage to his fauna from the Carapita formation of Venezuela. As he points out, this similarity may be due largely to environment.

AGE OF THE HACKBERRY ASSEMBLAGE

Evidence from the Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., and other deep wells in the Gulf Coast indicates that the Hackberry assemblage overlies beds carrying typical Vicksburg fossils, at least in regions where the Hackberry assemblage is not found at extreme depths. Of course, it is impossible to say what happens to the two faunas far down-dip. The Hackberry assemblage, then, would appear to be definitely of younger age than Vicksburg. Its exact age will depend upon where the top of the Oligocene is placed, which is an open question at present. I am inclined to believe that the Hackberry assemblage is equivalent in part to the Chickasawhay beds (Hazzard, 1934), but that it reflects a very different environment.[1] A great deal more work must be done along this line. I do not mean to imply that the Hackberry assemblage is exactly equivalent in age to the fauna of the Huasteca, or Alazan, of the Tampico region, Mexico, or to that of the beds at Finca Adelina, Matanzas Province, Cuba. Sufficient evidence for such a conclusion is not available, since it would require a detailed knowledge of widely separated areas, as well as a careful consideration of environments. At any rate, the number of species which the Hackberry assemblage has in common with these two faunas is very striking.

ACKNOWLEDGMENTS

I am greatly indebted to A. D. Ellis, Jr., for careful work done on the illustrations. R. Wright Barker kindly furnished material from the Huasteca, or Alazan, of the Tampico region, Mexico. Dorothy K. Palmer supplied an excellent suite of material from Finca Adelina, Matanzas Province, Cuba. J. A. Cushman generously gave both opinions and specimens of Foraminifera. H. D. Hedberg supplied foraminiferal material from Venezuela. A. R. Mornhinveg aided the preparation of the check list. H. V. Howe and M. C. Israelsky provided helpful comments and criticism. A. J. Bauernschmidt, Jr., kindly secured permission for me to make use of samples from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex. C. E. Manion rendered a like service concerning samples from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron

[1] EDITOR'S NOTE.—The Chickasawhay beds are classed by the United States Geological Survey as a part of the Vicksburg group.

Parish, La. Shirley L. Mason gave helpful advice about the preparation of the check list and map. Eli T. Monsour gave interesting information concerning the Huasteca, or Alazan, of the Tampico region, Mexico.

SYSTEMATIC DESCRIPTIONS

Family LITUOLIDAE

Genus AMMOBACULITES Cushman

AMMOBACULITES NUMMUS Garrett, n. sp.
Plate 40, figures 1*a*, *b*, 2

Test elongate, compressed, early portion coiled, later portion uncoiled and comprising most of test; chambers very indistinct in early portion, becoming more distinct in later portion; sutures indistinct; wall arenaceous, grains of moderate size; aperture large, terminal, rounded, in well-preserved specimens with a distinct tapering neck.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,919, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 7,752–7,754 feet): Length, 1.55 mm; width, 0.53 mm; thickness, 0.30 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,920, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 7,752–7,754 feet): Length, 1.40 mm; width, 0.50 mm; thickness, 0.34 mm.

Remarks.—This large species is unusually distinctive for the genus, and seems to have stratigraphic significance. Specimens typically have a distorted appearance.

Family NONIONIDAE

Genus NONION Montfort

NONION LUNATUM Garrett, n. sp.
Plate 40, figures 3*a–c*, 4

Test longer than broad, consisting of 10 to 12 chambers, last 2 to 4 chambers projecting toward the umbilical region; periphery rounded; umbilical region exposed, deeply depressed; sutures distinct, curved, slightly depressed; wall smooth; aperture a low arched opening immediately below a slightly depressed area at the base of the apertural face.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,921, from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron Parish, La., from core at 6,006–6,026 feet): Maximum diameter, 0.33 mm; thickness, 0.20 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,922, from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron Parish, La., from core at 6,006–6,026 feet): Maxi-

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EXPLANATION OF PLATE 40

FIGS. *1a, b, 2—Ammobaculites nummus* Garrett, n. sp. *1a*, Side view; *1b*, edge view, holotype no. 1,919, ×26. *2*, Side view, paratype no. 1,920, ×26. Hackberry fauna, Texas (p. 314)

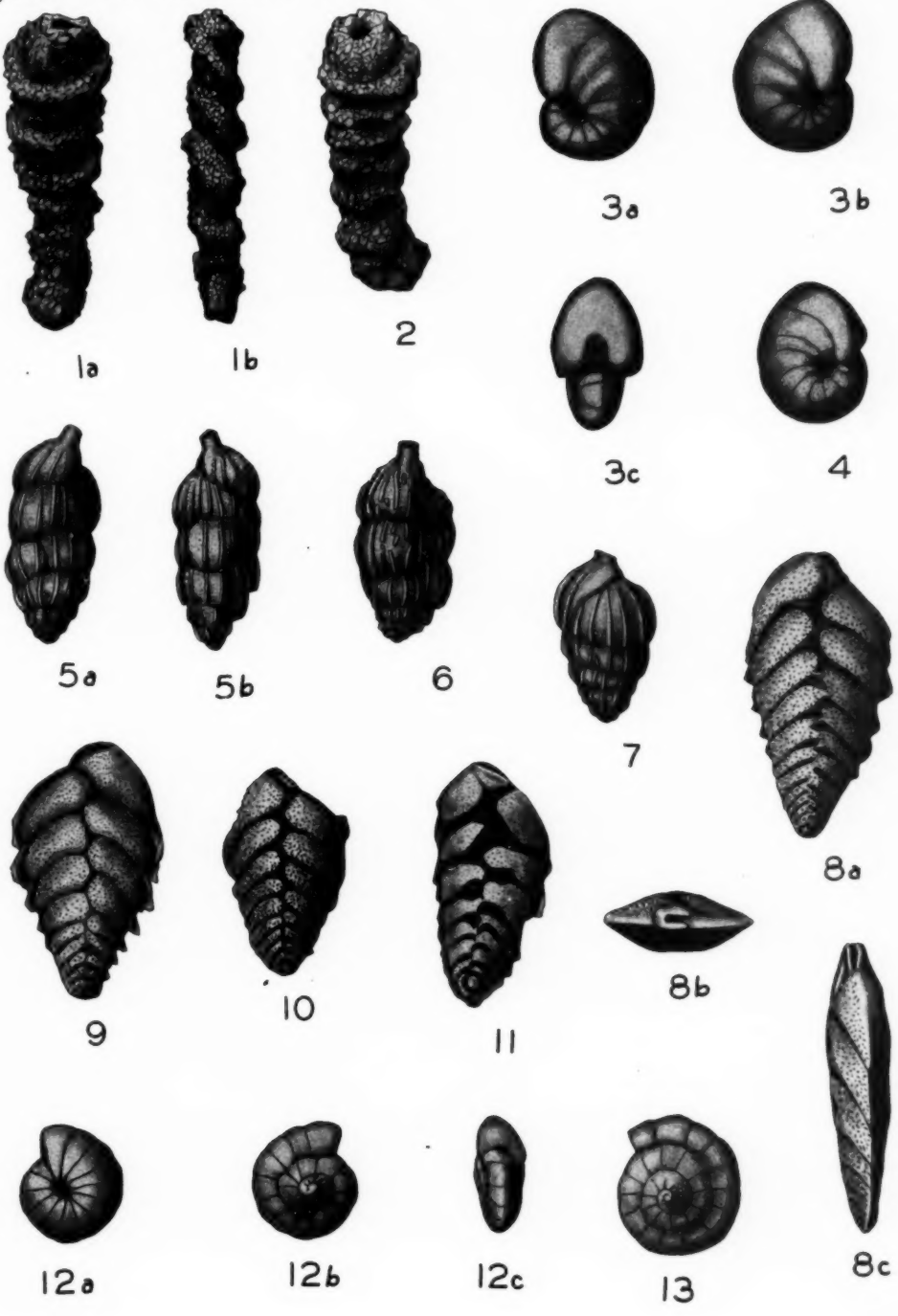
3a, b, c, 4—Nonion lunatum Garrett, n. sp. *3a*, Side view; *3b*, side view; *3c*, apertural view, holotype no. 1,921, ×55. *4*, Side view, paratype no. 1,922, ×55. Hackberry fauna, Louisiana. (p. 314)

5a, b, 6, 7—Uvigerina stephensoni Garrett, n. sp. *5a*, Side view; *5b*, side view, paratype no. 1,924, ×55. *6*, Side view, paratype no. 1,925, ×55. *7*, Side view, holotype no. 1,923, ×55. Hackberry fauna, Texas, Louisiana. (p. 315)

8a, b, c, 9, 10—Bolivina perca Garrett, n. sp. *8a*, Side view; *8b*, apertural view; *8c*, edge view, holotype no. 1,926, ×55. *9*, Side view, paratype no. 1,927, ×55. *10*, Side view, paratype no. 1,928, ×55. *Marginulina idiomorpha* zone, Middle Tertiary, Texas. (p. 315)

11—Bolivina mexicana Cushman var. Side view, hypotype no. 1,929, ×55. Hackberry fauna, Texas. (p. 315)

12a, b, c, 13—Gyroidina scalata Garrett, n. sp. *12a*, Ventral view; *12b*, dorsal view; *12c*, apertural view, holotype no. 1,930, ×55. *13*, Dorsal view; paratype no. 1,931, ×55. Hackberry fauna, Louisiana. (p. 316)



Garrett, Tertiary Foraminifera

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mum diameter, 0.34 mm; thickness, 0.18 mm.

Remarks.—This species appears closely related to the genus *Nonionella*.

Family BULIMINIDAE

Genus BOLIVINA d'Orbigny

BOLIVINA PERCA Garrett, n. sp.

Plate 40, figures 8*a–c*, 9, 10

Test elongate, compressed, thickest along the median line, broadest across the base of final chambers; periphery acute, with a narrow serrate keel of clear material; chambers 9 to 12 on each side in well-developed specimens, and averaging 11; sutures distinct, slightly curved, of clear material, limbate in most specimens, distinctly raised near the median line; surface of chambers smooth, with numerous coarse punctations, causing a frosted appearance; aperture elongate, with a distinct lip.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,926, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 6,420–6,422 feet): Length, 0.65 mm; width, 0.28 mm; thickness, 0.14 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,927, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 6,420–6,422 feet): Length, 0.60 mm; width, 0.33 mm; thickness, 0.12 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,928, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 6,420–6,422 feet): Length, 0.47 mm; width, 0.27 mm; thickness, 0.14 mm.

Remarks.—In this species the development of the peripheral keel varies considerably. This may be due partly to the amount of wear suffered by each specimen. *Bolivina perca* resembles both *B. mexicana* Cushman and *B. alazanensis* Cushman but differs from them in details of shape and structure. It differs markedly from *B. mexicana* in being more coarsely punctate and from *B. alazanensis* in having more limbate sutures and in being much more coarsely punctate. This species occurs stratigraphically above the Hackberry assemblage, but is figured for purposes of comparison with the other species of *Bolivina* mentioned above.

BOLIVINA MEXICANA Cushman var.

Plate 40, figure 11

Bolivina mexicana CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 1, pt. 4, p. 81, pl. 12, fig. 2; *1927*, Jour. Paleontology, vol. 1, p. 161, pl. 28, fig. 9; *1937*, Cushman Lab. Foram. Research, Special Pub. 9, p. 66, pl. 8, fig. 8.

The following description is quoted from the first reference given.

Test much compressed, the early portion with a slight keel, later chambers developing a wider keel; chambers of the early portion low, several times as broad as high, gradually increasing in height as added until in the adult the chambers are only slightly greater in width than in height, inflated slightly in later development; sutures distinct, in the early portion appearing at the surface as a double line between the chambers, in later development less marked and slightly obscured by a slight imbrication of the chambers; wall smooth, finely punctate; aperture elongate with a slight lip.

Length up to 1.2 mm.

Dimensions of hypotype (Louisiana State Univ. Mus., no. 1,929, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 7,566–7,568 feet): Length, 0.56 mm; width, 0.24 mm; thickness, 0.12 mm.

Remarks.—Well-preserved specimens from cores from Gulf Coast wells have not been available, but a suite of specimens from cuttings in the Hackberry field, Cameron Parish, La., is in excellent condition. These specimens are almost identical with some from Mexican localities.

Genus UVIGERINA d'Orbigny

UVIGERINA STEPHENSONI Garrett, n. sp.

Plate 40, figures 5*a–b*, 6, 7

Test small, fusiform, rather elongate; chambers numerous, inflated, in the final portion loosely arranged and tending to

become uniserial; periphery lobulate; sutures depressed; costae numerous, well defined, often high, not confluent with those on adjacent chambers; in many specimens costae in later portion of test tend to become broken into spines or nodes, and final chambers may be quite hispid; aperture small, terminal, with a fragile, tapering neck, which is broken in many specimens.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,923, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 7,771–7,773 feet): Length, 0.37 mm; width, 0.23 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,924, from Magnolia Petroleum Company, no. 1, H. B. Funchess, Jr., Jefferson County, Tex., from core at 7,771–7,773 feet): Length, 0.51 mm; width, 0.20 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,925, from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron Parish, La., from core at 6,006–6,026 feet): Length, 0.45 mm; width, 0.22 mm.

Remarks.—This species is quite similar to *Uvigerina gardnerae* Cushman. However, the same can be said of many small species of *Uvigerina* of various ages.

Family ROTALIIDAE

Genus GYROIDINA d'Orbigny

GYROIDINA SCALATA Garrett, n. sp.

Plate 40, figures 12*a–c*, 13

Test very small, dorsal side flattened, ventral convex, last coil consisting of 12 to 14 chambers; periphery sharply rounded; umbilical region small, deeply depressed; sutures fine, distinct, usually flush, sometimes slightly depressed, radial or slightly curved; wall smooth; aperture a very low opening at the base of the apertural face on the ventral side.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,930, from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron Parish, La., from core at 6,006–6,026 feet): Maximum diameter, 0.27 mm; thickness, 0.12 mm. Dimensions of paratype (Louisiana State Univ. Mus., no. 1,931, from Superior Oil Company, no. 1, D. Hebert, Hackberry field, Cameron Parish, La., from core at 6,006–6,026 feet): Maximum diameter, 0.33 mm; thickness, 0.14 mm.

Remarks.—This small species resembles *Gyroidina depressa* (Alth) and *G. laevis* d'Orbigny.

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CONODONTS FROM THE PRAIRIE DU CHIEN (LOWER ORDOVICIAN) BEDS OF THE UPPER MISSISSIPPI VALLEY

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ABSTRACT

A considerable variety of conodonts, recently found in the Lower Ordovician Prairie du Chien group of the Upper Mississippi Valley, are here described. Prolific faunas were obtained from the Oneota dolomite and the Shakopee dolomite. The Prairie du Chien conodonts are referable to twelve genera, four of which are described for the first time. Simple or distacodid teeth predominate, and the few compound forms represented are primitive types. The faunas contain many elements common to those described from Lower Ordovician rocks of the Baltic region and from the "Jefferson City" dolomite of Missouri. The Oneota conodonts seem to be older than any previously recorded.

Fossils are not abundant in the Prairie du Chien beds of the Upper Mississippi Valley and most of those that have been described are poorly preserved. Primarily for this reason, the precise age and relationships of these beds have long been in question. During the summer of 1934, I found in shale samples from the Prairie du Chien a few conodonts that proved to be much better preserved than molluscs and other fossils which these beds had yielded previously and therefore it seemed that they might be very helpful in solving certain stratigraphic problems that have arisen in regard to these beds (Trowbridge and Atwater, 1934, pp. 65–73). Accordingly, in 1936, an attempt was made to collect systematically from these beds. The conodonts were not found to be abundant, but a considerable fauna was obtained at several rather widely separated horizons and localities.

THE PRAIRIE DU CHIEN GROUP

The Prairie du Chien beds, which consist largely of dolomite, are a conspicuous unit that outcrops extensively in the Driftless Area of southeastern Minnesota, southwestern Wisconsin, and northeastern Iowa. Scattered exposures occur northwest and northeast of this area, and small inliers have been found in Illinois. These beds are underlain by the Jordan sandstone of Cambrian age and overlain by the Middle Ordovician St. Peter sandstone. Thicknesses in the outcrop area generally vary between 100 and 250 feet; but as a result of pre-St. Peter erosion, there is much variation in short distances.

Since this study is primarily paleontological, an attempt is made to employ a conservative stratigraphic nomenclature; therefore, the Prairie du Chien is used as a group, composed of the Oneota and Shakopee formations. This usage of the terms Oneota and Shakopee is essentially the same as that which has been generally accepted since their definition by Hall and Sardeson in 1895. Winchell first used Shakopee in 1874 to apply to exposures of the upper part of the "Lower Magnesian." In 1882, Wooster applied the term New Richmond to a sandstone within the Prairie du Chien dolomite, and used the name Willow River for the dolomite which lies above the New Richmond and below the St. Peter. Later, in 1886, Winchell delimited the Shakopee and recognized that both he and Wooster had confused the New Richmond with the Jordan. Then in 1891, McGee proposed the name Oneota for the lower dolomite division. In 1906, Bain included all of this dolomite and sandstone in one unit to which he applied the name Prairie du Chien. There has been some question as to whether the upper dolomite should be designated as

Shakopee or as Willow River. The New Richmond sandstone, here regarded as a member of the Shakopee, has been interpreted as a distinct formation by some authors.

As generally recognized, on the basis of megafossils, the Oneota is the direct or partial equivalent of the Gasconade of Missouri, and the Shakopee may be equivalent to the Cotter of Missouri (Stauffer, 1937, p. 67). Most authors regard these strata as belonging in the Lower Ordovician Beekmantown or Canadian series. Recognition of the Ozarkian division of Ulrich would involve the Oneota formation, at least.

In addition to the interbedded sandstones locally present in the Prairie du Chien, numerous thin shale beds occur in most well-exposed sections. These plastic shale deposits are never more than a few inches thick but are continuous across single exposures. All of the conodont faunas described in this paper came from such layers, at least some of which are believed to be composed of metabentonite (Bays, 1937).

CONODONTS FROM PRAIRIE DU CHIEN BEDS

Productive material was collected from the Prairie du Chien beds at widely separated localities in Minnesota, Wisconsin, and Iowa. The lowest horizon represented is that of the "Blue Earth" beds at Mankato, Blue Earth County, Minn. Conodonts occur directly below the Oneota dolomite exposed in a road cut in the southwest part of the town (sec. 18, T. 108 N., R. 26 W.). Also, a few specimens were found in samples from the Oneota in a quarry in the northern part of Mankato (SE. 1/4 sec. 6, T. 108 N., R. 26 W.). In every case, forms obtained at the latter locality are conspecific with those found in the "Blue Earth" fauna. Since the "Blue Earth" beds are somewhat local in extent and carry a typical Oneota fauna, they are regarded in this report as part of the Oneota rather than as a separate formation.

The "west quarry" at Shakopee in Scott County, Minn. (sec. 1, T. 115 N., R. 23 W.), is moderately productive of conodonts. There has been considerable controversy over the age of the beds at this locality (Powers, 1935, pp. 442–445), and unfortunately the evidence I was able to obtain is not conclusive. There is some reason to believe that the strata here belong to the Oneota, but because this section has been regarded as typical of the Shakopee and because its faunal assemblage is not typical of the Oneota, I refer the section at this locality to the Shakopee. The conodonts described came from about 6 feet above the base of the quarry, in which about 25 feet of dolomite are exposed.

Near Lanesboro, Fillmore County, Minn., both the Shakopee and Oneota formations are exposed in a road cut (sec. 35, T. 103 N., R. 10 W.). Shales from three horizons at this locality [beds 1, 5, and 6 of Stauffer (1935, p. 128)] were found to be moderately productive. The first of these is in the lower Oneota and the latter two are in the Shakopee.

A prolific fauna was found to occur in the Oneota of Allamakee County, Iowa, 5 miles north of the town of Marquette (sec. 17, T. 90 N., R. 3 W.), where the Prairie du Chien is about 200 feet thick. In a road cut, samples collected about 50 feet below the St. Peter sandstone produced a few forms, and numerous individuals were found about 90 feet below the St. Peter.

A locality in Iowa County, Wis., about 2 miles south of the town of Clyde (sec. 7, T. 7 N., R. 3 E.), provided the most prolific Shakopee conodont fauna yet discovered. Discontinuous natural exposures and road cuts extend from the Jordan sandstone to the Platteville formation. The Oneota is here about 80 feet thick and the "New Richmond" sandstone is well developed. The conodont fauna obtained came from the north wall of a quarry approximately 25 feet above the "New Richmond."

Some 85 miles northeast of the Iowa County locality, a conodont fauna was

TABLE 1.—DISTRIBUTION OF CONODONT SPECIES IN THE PRAIRIE DU CHIEN.

	ONEOTA			SHAKOPEE			
	Blue Earth County, Minnesota	Fillmore County, Minnesota	Allamakee County, Iowa	Iowa County, Wisconsin	Fond du Lac County, Wisconsin	Fillmore County, Minnesota	Scott County, Minnesota
Acodus oneotensis, n. sp.	C	C	C	—	—	—	—
Acontiodus iowensis, n. sp.	—	C	C	—	—	—	—
Acontiodus propinquus, n. sp.	C	—	?	—	—	—	—
Acontiodus staufferi, n. sp.	—	—	—	R	—	—	—
Clavohamulus densus, n. sp.	—	C	C	—	—	—	—
Distacodus? gracilis, n. sp.	—	—	—	R	R	R	R
Distacodus? simplex, n. sp.	—	—	R	—	—	—	—
Drepanodus lineatus, n. sp.	C	—	—	—	—	—	—
Drepanodus subarcuatus, n. sp.	C	—	C	A	C	C	C
Drepanodus tortus, n. sp.	—	—	—	R	—	—	—
Oistodus concavus	R	—	—	R	—	—	—
Oistodus erectus, n. sp.	R	R	R	R	—	—	—
Oistodus inclinatus	R	R	—	R	—	—	—
Oistodus mehli, n. sp.	C	—	R	—	—	—	—
Oistodus pandus	R	—	—	—	—	—	—
Oistodus? triangularis, n. sp.	C	—	—	—	—	—	—
Paltodus bassleri, n. sp.	R	—	—	—	—	—	—
Paltodus variabilis, n. sp.	C	C	C	—	—	—	—
Scolopodus quadraplicatus	—	—	?	A	C	C	C
Scolopodus shakopeensis, n. sp.	—	—	—	R	—	R	—
Scolopodus sulcatus, n. sp.	R	—	—	—	—	—	—
Ulrichodina prima, n. sp.	—	—	—	C	—	—	—
Ulrichodina wisconsinensis, n. sp.	—	—	—	C	—	—	—
Ulrichodina? deflexus, n. sp.	—	—	—	—	—	R	—
Acanthodus uncinatus, n. sp.	R	—	—	—	—	—	—
Loxodus bransoni, n. sp.	R	—	C	—	—	—	—
Cordylodus intermedius, n. sp.	R	—	—	—	—	—	—
Cordylodus subangulatus, n. sp.	R	—	—	—	—	—	—

A, abundant; C, common; R, rare.

collected in a quarry at Ripon, Fond du Lac County, Wis. (sec. 20, T. 16 N., R. 14 E.). The St. Peter sandstone is lacking in this section, but is present a very short distance to the south. All of the samples studied from this locality came from within 15 feet of the top of the Prairie du Chien, which is believed to be 113 feet thick here (Powers, 1935, pl. 49). The fauna is much like the known Shakopee faunas and is therefore assigned to that formation.

Most of the numerous Prairie du Chien shale samples examined contained no conodonts or only a few isolated individuals. In addition to localities mentioned above, several specimens were obtained from Dane, Grant, and Pierce counties, Wis.[1]

[1] Since this manuscript was completed, Prairie du Chien conodonts have been found in a city well at East Dubuque, Jo Daviess County, Ill. (curb elevation 620 feet above sea level). The Prairie du Chien there is about 235 feet thick and it yielded conodonts at two horizons. An upper zone, 230 to 250 feet in depth and 15 to 35 feet below the top of the unit, was found to contain *Drepanodus*, *Oistodus*, and *Scolopodus*. A lower zone, about

Practically all of the samples which yielded conodonts contained numerous phosphatic plate fragments. Most of these are lamellar in structure, elongate in shape, and roughly triangular in cross section. Other fragments are platelike and some bear surface ornamentation on one side. Association of these fragments with conodonts, both in the fauna under consideration and in younger strata, suggests a possible relationship. Conodonts and similar plate fragments occur in the Middle Ordovician of the Rocky Mountain region with undoubted fish remains, but their association may be incidental.

STRATIGRAPHIC SIGNIFICANCE OF CONODONT FAUNAS

Even preliminary work on the Prairie du Chien conodonts indicates that there are conspicuous differences between the Shakopee and Oneota faunas. Certain genera characteristic of the Oneota apparently do not persist into the Shakopee and others seem to have been introduced during Shakopee times. Furthermore, in the few cases where genera continue from one formation to the other, structural evolution can generally be traced. However, a few simplified types, which usually constitute the most conspicuous faunal elements, have considerable vertical range and these are of little stratigraphic value. There is also some conflicting evidence, for the collections from the Oneota contain a few units for which there is no counterpart in the Shakopee but which appear to be represented in Middle Ordovician strata. Explanation of such apparent anomalies must await future studies.

The genus *Acodus* has proved to be one of the best indices for the Oneota and it does not occur in the Shakopee. The species *A. oneotensis* is not close to any described form, but occurs commonly in the Oneota at Mankato and Lanesboro, Minn., and near Marquette, Iowa. *Paltodus* is likewise confined to the Oneota, and *P. variabilis* constitutes an abundant element of the fauna at all three localities here recorded. The unique genus *Clavohamulus* has been found at two Oneota localities: Lanesboro, Minn., and Marquette, Iowa. Additional collecting may establish this as a diagnostic Oneota genus.

All of my collections from the Shakopee contain numerous representatives of *Scolopodus quadraplicatus*. Although this species occurs in the Oneota in northeastern Iowa, it seems, in general, to be a reliable guide fossil for the Shakopee. Individual specimens of the Oneota representatives of this species agree well with Shakopee specimens, but a majority of those obtained from the Oneota show variation from the typical form and may prove to be specifically distinct. The other representative of *Scolopodus* which occurs in the Shakopee, *S. shakopeensis*, has been found at but two localities, and it is not abundant at either of them. Specimens of *Ulrichodina* are usually rare, but their distinctive form increases their value as an index for the Shakopee horizon. Two species of this genus were found in the Shakopee near Clyde, Wis., and one near Lanesboro, Minn.

Genera which range through both lower and upper Prairie du Chien generally show specific differences. For example, *Acontiodus iowensis* of the Oneota formation near Marquette, Iowa, and Lanesboro, Minn., is distinct from and more or less intermediate between the congeneric species which occur in the "Blue Earth" and the Shakopee. Apparent evolutionary trends in such a simplified unit as *Distacodus*? are probably unreliable, but the relatively stout Oneota forms differ appreciably from the slender Shakopee species. Most species of *Oistodus* and *Drepanodus* are generalized prolific types which have much the same appearance throughout their range. Many unique species are represented in the "Blue Earth" fauna, and

100 feet below the first, supplied representatives of all these genera and, in addition, a single specimen of the unique genus *Ulrichodina*.

forms such as *Drepanodus lineatus*, *Oistodus? triangularis*, *Paltodus bassleri*, and *Scolopodus sulcatus* are not known to occur elsewhere. Compound teeth are so rare in Prairie du Chien faunas that they are of little stratigraphic value—the restricted occurrence of *Acanthodus*, *Cordylodus*, and *Loxodus* in the Oneota is probably of little significance.

In summary, the Oneota and Shakopee conodont faunas are closely related and contain several genera and a few species in common. Yet there are noteworthy differences between the two and these might justify recognition of the units as distinct formations. The Glenwood shale, which is the next conodont-bearing unit above the Prairie du Chien, has an almost entirely different generic assemblage. Distacodid teeth have become of secondary importance and various types of compound teeth have been introduced. Although only the St. Peter sandstone intervenes between the Prairie du Chien and Glenwood, the faunal differences suggest that considerable time elapsed between the deposition of the two.

The only described conodont fauna that can be compared readily with the Prairie du Chien faunas is that obtained by Branson and Mehl (1933) from a single locality in the "Jefferson City" dolomite of east-central Missouri. These authors state that

> the name of the formation is not used in the restricted sense. The conodonts were found near the top of the formation, in the Powell zone.

There is little or no Lower Ordovician exposed in the 300 or 400 miles which intervene between the Missouri outcrops and those of the Upper Mississippi Valley, but well logs show that the stratigraphic series is continuous.

Both of the forms which, as mentioned above, are considered to be diagnostic of the Shakopee in the Upper Mississippi Valley are represented by closely related species in the "Jefferson City." *Scolopodus quadraplicatus* was originally described from Missouri and is abundant in the Shakopee. *Ulrichodina abnormalis* of the "Jefferson City" formation appears to be very similar to several congeneric forms that occur in the Shakopee. The ubiquitous genera *Drepanodus* and *Oistodus* are well represented in both the "Jefferson City" and the Shakopee faunas. However, the Oneota fauna shows few close similarities with that of the "Jefferson City," except in the case of long-ranging forms. The genera *Acodus* and *Paltodus* are characteristic of the Oneota faunas, but congeneric specimens were described by Branson and Mehl. Clearly, then, the Shakopee and the "Jefferson City" faunas are much more closely related to each other than to that of the Oneota. Although some elements are present in both the Shakopee and "Jefferson City" that do not occur in the other, tentative correlation of the two is compatible with the available evidence.

Much of the conodont material from the Baltic region described by Pander in 1856 came from Lower Ordovician strata. Schmidt (1882, p. 518) states that Pander's specimens came largely from the glauconitic sand now included in the lower Balticport group, which is the lowest unit of the Estland series. The Estland is considered to be approximately equivalent to the Arenig (Grabau, 1936, p. 204). Pander's numerous illustrations are of remarkably high quality and most of the pertinent information concerning his species may be obtained from the descriptions and figures which he published. However, until his material has been restudied in the light of modern methods of paleontological and stratigraphical investigation, many questions concerning the fauna will remain unanswered.

The Lower Ordovician faunas of the Mississippi Valley resemble the faunas studied by Pander more than any others that have been described. Most of the genera represented in the Lower Ordovician of the Mississippi Valley were established by Pander and are based on specimens from the Baltic region. Although no compound teeth have been

reported previously from the Lower Ordovician of this country, species referable to three genera (*Cordylodus*, *Acanthodus*, and *Loxodus*) occur in the Prairie du Chien beds and are described below. The latter two genera are new. Species from northern Europe referred to *Acontiodus*, *Drepanodus*, *Oistodus*, *Paltodus*, *Scolopodus*, and *Cordylodus* all have close counterparts in the Lower Ordovician of central North America. Although no conspecific examples are recognized, it seems very significant that specific similarities can be pointed out in such widely separated localities. In so far as is now known, all Lower Ordovician conodont faunas are composed entirely or predominantly of distacodid teeth. The time at which compound forms first appeared remains to be established; the relative stage of development can therefore be of little assistance in determining respective ages of Baltic and Mississippi Valley conodont faunas. The primitive compound tooth, *Cordylodus*, is represented in both Europe and America, but Pander's genera, *Prioniodus* and *Belodus*, have not been observed in the Lower Ordovician of America. The occurrence of these two genera in strata younger than Lower Ordovician might be taken to indicate that the fauna of the Baltic region is somewhat younger than that described below.

In 1907, Smith described from several localities in the southern uplands of Scotland some conodonts which may be Lower Ordovician in age. The published descriptions and illustrations of his specimens are inadequate in most cases and the horizons cited do not seem to be well established. A portion of his material is stated to be from the Arenig and the remainder was believed by him to have come from "Arenig-Llandeilo" strata. The typical examples of *Hindeodella* illustrated suggest a Devonian or Carboniferous age for the containing beds.

CLASSIFICATION OF CONODONTS

Faunas older than those described below from the lower part of the Prairie du Chien beds are not known at present. Nevertheless, the high degree of complexity and diversity attained in the Oneota dolomite indicates that older faunas probably exist.

In his pioneering monograph, Pander (1856) divided conodonts into two main groups: "e˙nfache" and "zusammengesetzte" teeth. Seventy years later, Ulrich and Bassler proposed that four families be recognized, and their family, Distacodidae, corresponds directly to Pander's first unit. Numerous intermediate forms indicate beyond reasonable doubt that compound teeth were derived by several distinct lines of evolution. This fact suggests that at least the families Prioniodidae and Prioniodinidae of Ulrich and Bassler are polyphyletic. Subsequent work on the genus *Prioniodus* necessitates a redefinition of the family it typifies, and numerous genera such as *Phragmodus* and *Trichognathus* do not logically belong in any of the established families. Important structural differences have been pointed out by Branson and Mehl, who (1933, p. 23) state that as

> the arrangement of genera in already proposed or new family groups is of questionable value at the present time . . . we do not feel justified in designating relationships beyond those suggested by generic reference.

The Prairie du Chien conodont faunas are composed almost exclusively of simple or distacodid teeth, and although the few compound forms in the faunas are considered separately, there is no intention of indicating phylogenetic relationships.

Typical distacodid teeth are comparatively unimportant in conodont faunas younger than Lower Ordovician, and with one or two possible exceptions not a single genus has been proposed since Pander's work of 1856. Pander's type material has never been restudied and precise relationships of the groups remain to be established. Pander realized that his genera were not distinctly set off from one another for he states:

Zwischen diesen Extremen [forms representative of the genera] giebt es eine Menge Formen.

The situation is further complicated by the fact that genotypes (by subsequent designation) are in many cases not truly representative of the group of species originally referred to a particular genus. It is impractical at this time to attempt precise definitions of existing genera, and in many cases the interpretations employed in this report are those used by Branson and Mehl in their studies of Ordovician and Silurian conodont faunas.

Pander based his genera of simple teeth primarily on the shape of the cross section of the cusp, but it now seems probable that this characteristic is of secondary importance. Many species show considerable variation in this respect and representatives of a single closely related unit may thus be referred to more than one genus. The nature of the base and the relation of the base to the cusp appear to be fundamental characteristics upon which generic definitions should rest. Variations in structural features, such as the shape of the cross section or amount of curvature taken alone, may be regarded as of specific importance only. For example, if we consider the group of *Paltodus gracilis*, we find that it includes forms which are abundant in the Middle and Upper Ordovician and which are the only distacodids known to extend into the Silurian. Variation within this group results in cross sections considered to be typical of the genera *Paltodus*, *Scolopodus*, and *Acodus*. The general morphology of the specimens, however, indicates that in all phases of this group of species the teeth are closely related, and they should probably be referred to a single genus which has no direct relationship to the three genera mentioned above.

Since the collections under consideration consist entirely of isolated teeth, they yield no new information in regard to the question of the biologic relationships of conodonts. The investigation involved the examination of hundreds of nearly perfect specimens and some interesting facts concerning their morphology have been noted.

Pander's illustrations clearly show the growth lamellae present in typical conodonts. In distacodids, growth took place radially from what is now the tip of the basal cavity. The tooth must have started as a minute cap which was extended upward to form the cusp, and down and outward to form the flangelike base enclosing the basal cavity. Presumably, only the tip of the tooth was exposed during the life of the animal and, as a result, this portion is somewhat altered and discolored in many specimens. A trace of the tip extends longitudinally from the apex of the basal cavity to the point of the cusp, and forms a white line called the growth axis. Compound teeth apparently do not differ greatly from distacodids in their method of growth; denticles are added posteriorly during ontogenetic development and as they grow upward from the bar a trace of the point remains, extending down into the bar as a whitened axis. This observation seems to indicate that Stauffer's statement (1935a, p. 599) that "denticles are inserted into the base and are only secondarily a part of it" is probably not correct.

A number of these delicate teeth show evidence that the point of the tooth or even the major portion of the cusp was broken off during the life of the animal and then partially restored. Typically, the replaced portion does not attain the dimensions of the original (pl. 41, fig. 31), and in many cases it is out of alignment with the original axis of growth (pl. 41, fig. 29). Only a few cases were found in which irregularities of growth or casualties had affected the base of the teeth. The significance of such repair in conodonts becomes apparent when it is discovered that a seemingly aberrant form merely represents a damaged individual of a common species. Long sharp points and thin keels indicate that the teeth may have been used for grasp-

ing prey; none of those examined by me seems to have suffered wear or abrasion as a result of use by the animal.

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SYSTEMATIC DESCRIPTIONS

Genus ACODUS Pander, 1856

This genus includes asymmetrical forms distinguished primarily by a single lateral carina and possessing anterior and posterior keels. Five species were originally referred to this genus, two more species have been described from the Lower Ordovician of Missouri, and another is described below from strata of this series. A single species from the Bainbridge (Silurian) has been placed in this genus, but does not appear to belong there. In the Upper Mississippi Valley, *Acodus* is widespread and abundant in the Oneota but is not known to occur in the Shakopee.

Genotype: *Acodus erectus* Pander.

ACODUS ONEOTENSIS Furnish, n. sp.
Plate 42, figures 26–29

Teeth having one side more or less flattened and a strong carina flanked by grooves on the other side; carina forming a buttress against the expanded base, which is nearly circular in outline; base only moderately set off from cusp, expansion of the tooth from point to base being uniform and gradual. Some individuals are regularly curved and others are nearly straight; a slight inward lateral flexure usually exists. Representatives of this species from Mankato and Lanesboro, Minn., typically show a low narrow carina on the flattened outer side opposite the strong carina. A few specimens from Mankato show low carinae flanking the prominent lateral carina. The basal cavity is fairly large and cone-shaped, but the growth axis is not clearly discernible on any of the syntypes.

Remarks.—This species is a conspicuous element in the several Oneota faunas studied but was not found to occur in the Shakopee formation. There is considerable variation within this species, but it does not seem advisable to propose more than a single name for the unit. No described forms seem to be particularly close to this one and the congeneric species from Missouri have the base recurved and expanded.

Occurrence.—Common in the "Blue Earth" beds at Mankato, Minn., and the Oneota near Lanesboro, Minn., and near Marquette, Iowa

Syntypes.—State Univ. Iowa, nos. 1249–1255.

Genus ACONTIODUS Pander, 1856

A fairly well-defined group of species consisting of bilaterally symmetrical teeth compressed anteroposteriorly, rounded anteriorly, and grooved posteriorly. Three species are described below, and three have been described previously from the Baltic region. Representatives of this genus are common in the Oneota, but comparatively rare in the Shakopee. *A. alveolaris* Stauffer of the Middle Ordovician of Minnesota seems to be a typical representative of the genus.

Genotype: *Acontiodus latus* Pander.

ACONTIODUS IOWENSIS Furnish, n. sp.
Plate 42, figures 16, 17

Slightly curved teeth with only a very small amount of expansion at base; anterior side broad and rounded, lateral portions keeled, and posterior side marked by two prominent grooves flank-

ing the posterior carina, which may in turn be slightly indented. The lateral expansion, from base to point, is moderately rapid but the anteroposterior dimension changes slowly. Outline of base elliptical, with lateral dimension the greatest. Cusp recurved just above base, but the basal plane forms a large angle with the axis of the cusp. Basal cavity quite shallow, conical, with apex near anterior side. The cusp of all syntypes is altered to opacity and therefore the growth axis was not observed. Lateral dimension appears to increase relatively during ontogenetic development, and there is appreciable variation in this detail among equal-sized specimens.

Remarks.—This form seems to be more closely similar to the genotype, *A. latus*, than any known species. *A. staufferi*, described below, is more greatly elongate than the species under consideration, and the base is not regularly elliptical in that form as it is in *A. iowensis*.

Occurrence.—Common in Oneota near Marquette, Iowa, and near Lanesboro, Minn.

Syntypes.—State Univ. Iowa, nos. 1256–1259.

ACONTIODUS PROPINQUUS
Furnish, n. sp.
Plate 42, figures 13–15

Forms included in this species are easily distinguished by the relatively deep posterior sulcus. They are bilaterally symmetrical and have a rounded anterior side which extends to the narrowly rounded posterolateral portion. Curvature of tooth is slight except at base of cusp, where it is abruptly recurved; base only slightly expanded, and inclined to axis at a low angle; basal cavity very shallow, but growth axis cannot be observed. Some specimens are expanded laterally to a greater extent than is typical and these may also have a low carina in the posterior sulcus.

Remarks.—Although these forms do not closely resemble any described species, they almost certainly belong to *Acontiodus*. The rapid lateral expansion, shallow basal cavity, and elliptical base are all characteristic of the genotype. A single small specimen from the Oneota near Marquette, Iowa, agrees well with typical representatives of this species, but does not have a deep posterior sulcus.

Occurrence.—Common in "Blue Earth" beds at Mankato, Minn., and possibly occurs in Oneota near Marquette, Iowa.

Syntypes.—State Univ. Iowa, nos. 1260–1262.

ACONTIODUS STAUFFERI
Furnish, n. sp.
Plate 42, figures 11, 12

Cusp slightly curved but bilaterally symmetrical; base expanded posteriorly almost normal to axis of cusp; tooth rounded anteriorly, keeled laterally, and marked by grooves posterolaterally. A simple posterior carina is characteristic of some specimens and in other cases the carina is broader and divided medially by a faint depression. As in other members of this genus, the basal cavity is relatively shallow. Growth axes are clearly visible and extend from apex of basal cavity to point of cusp.

Remarks.—Although *Acontiodus* is common and apparently widespread in the Oneota, this species is the only one known to occur in the Shakopee. It is not particularly representative of the genus and is quite variable.

Occurrence.—Rather rare in the Shakopee near Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1263, 1264.

Genus CLAVOHAMULUS
Furnish, n. gen.

Forms included in this genus differ in many respects from the usual type of distacodid conodont, but they are associated with typical conodonts and have much the same general appearance. A bulbous pitted basal portion, which is not excavated by a basal cavity, is joined to a slender bladelike cusp. *Cornuramia* of the "Arenig-Llandeilo"

beds of Scotland may be closely related, but there are many obvious differences. Representatives of *Clavohamulus* have been found only in the Oneota dolomite of the Upper Mississippi Valley.

Genotype: *Clavohamulus densus* Furnish, n. sp.

CLAVOHAMULUS DENSUS
Furnish, n. sp.
Plate 42, figures 18–21

Base distinctly set off and so greatly expanded laterally that basal outline is subelliptical in shape; in many cases the base is somewhat depressed, and it may be slightly warped to give a downward convexity. Cusp nearly straight and somewhat compressed laterally; both basal portion of cusp and base flattened anteriorly. No growth axis visible, but lamellae parallel to flattened anterior portion of tooth are discernible; lamellar portion is also colored brown whereas remainder of tooth is white. It appears that successive layers were secreted anteriorly, and that consequently much of the apparent growth is in an anterior direction. Anterior flattening suggests the possibility that teeth may have been associated as pairs in contact on these surfaces. Posterior portion of base marked by numerous rounded indentations which show a fair degree of linear arrangement; these minute indentations suggest scars of muscle attachment and present a contrast to the smooth hollow base of typical conodonts.

Remarks.—The description of this species is based primarily upon a single specimen of relatively large size (pl. 42, figs. 18, 19), and in all of the other syntypes the cusp is delicate and cylindrical rather than bladelike. *Cornuramia monodonta* Smith bears superficial similarity to the species under consideration. In that form, however, elongation of the base is parallel to the curvature of cusp rather than normal to it.

Occurrence.—Common in Oneota near Marquette, Iowa, and near Lanesboro, Minn.

Syntypes.—State Univ. Iowa, nos. 1265–1268.

Genus DISTACODUS Hinde, 1879

Pander originally established this unit and used the preoccupied name *Machairodus* for it. He included bilaterally symmetrical forms with strong anterior and posterior keels and lateral carinae. Asymmetrical forms somewhat intermediate between this type of tooth and related genera were also placed in the genus; unfortunately, the genotype is one of the latter. For this reason the generic relationships cannot be well established at present, and it seems best to retain the existing liberal concept of the genus. There are perhaps no species in the Prairie du Chien faunas that can be properly placed in this genus, and the two species referred to it below are merely simple types that cannot be readily classified generically. This genus has been reported from a number of horizons and localities in addition to the Lower Ordovician of the Baltic region, but most of these references are probably incorrect.

Genotype: *Distacodus incurvus* (Pander).

DISTACODUS? GRACILIS
Furnish, n. sp.
Plate 42, figure 23

Teeth simple, with no ornamentation on cusp, relatively elongate and delicately constructed. Cusp nearly straight but sharply recurved just above base, which is but slightly expanded; cross section of cusp subcircular but distinctly flattened posteriorly. Unaltered specimens show growth axis extending from apex of basal cavity near the anterior side of tooth directly to point of cusp.

Remarks.—This species is very closely related to *Scolopodus quadraplicatus*, with which it occurs in association. The simple rounded cross section serves to distinguish *Distacodus? gracilis* from all associated forms.

Occurrence.—Common in Shakopee at Ripon, Wis., and rare in the same

formation near Lanesboro, Minn., and Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1269–1273.

DISTACODUS? SIMPLEX
Furnish, n. sp.
Plate 42, figures 24, 25

Cross section of cusp subcircular. Specimens bilaterally symmetrical, or nearly so; curvature generally uniform and moderate, but amount of curvature somewhat variable. Expansion is relatively rapid and constant from base to cusp. The only distinguishing characteristic is the general simplicity of form.

Occurrence.—Rare in Oneota near Marquette, Iowa.

Syntypes.—State Univ. Iowa, nos. 1274, 1275.

Genus DREPANODUS Pander, 1856

Teeth simple, characterized by anterior and posterior keels and flattened sides, were originally included in this genus. Representatives of *Drepanodus* have been described from several localities besides those studied by Pander in the Baltic region. Hinde has recorded two species in the Ordovician of Ontario; Smith has referred one species from the Ordovician of Scotland to this genus; Hadding has described three species from this system in Norway; and Branson and Mehl have described three additional species from the Lower Ordovician of Missouri. The genus has likewise been found to occur abundantly in the Prairie du Chien beds of the Upper Mississippi Valley.

Genotype: *Drepanodus inflexus* Pander.

DREPANODUS LINEATUS
Furnish, n. sp.
Plate 41, figures 33, 34

Anterior and posterior keels occur on upper two-thirds of the tooth but not on lower third. Lateral carina anterior in position at base of cusp, but becoming lateral in position with appearance of anterior and posterior keels; it is obsolete at about median height of cusp. Cusp nearly straight but strongly recurved at base so that axis is about parallel to plane of base.

Remarks.—Other members of *Drepanodus* resemble this species in general morphology but do not characteristically possess lateral carinae. *D. lineatus* is represented by numerous specimens which resemble one another closely. Dextral and sinistral individuals are about equally abundant and considerable size-range is shown. A fairly stable associated unit, which is regarded as a variant of this species, has lateral carinae on each side of the cusp rather than on one side only.

Occurrence.—Known only in the "Blue Earth" beds at Mankato, Minn., where it occurs commonly.

Syntypes.—State Univ. Iowa, nos. 1276, 1277.

DREPANODUS SUBARCUATUS
Furnish, n. sp.
Plate 41, figures 25–32;
plate 42, figures 2, 3

?Drepanodus arcuatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 58, pl. 4, figs. 7, 8, 13, 16.

[*not*] *Drepanodus arcuatus* PANDER, *1856*, Monographie der Fossilen Fische des Silurischen System der Russisch-Baltischen Gouvernements, p. 20, pl. 1, figs. 2, 4, 5, 17, 30, 31, St. Petersburg.

Teeth simple, with straight cusp and slightly expanded base. Anterior and posterior keels produce a bladelike cusp, flattened laterally. Cusp strongly recurved just above base so that plane of base intersects axis of cusp at a low angle. Some large, well-preserved specimens have developed a very acuminate posterior keel just below the point of the tooth, which results in a slight expansion in the lateral outline. Since the cusp is thin and bladelike, most specimens are broken and many individuals show evidence of replacement in the apical portions. Apex of the conical basal cavity is very near anterior margin and growth axis is straight.

Remarks.—Considerable variation is

shown in the many specimens here referred to this species. One extreme is exemplified by specimens from the Shakopee near Lanesboro, Minn., which characteristically show the cusp to be relatively more slender than typical specimens, and rounded rather than keeled on the basal portions of cusp. Forms from this locality are somewhat smaller than the average from other localities, and the apparent differences may be due to this factor alone. The species described by Branson and Mehl as "*Drepanodus arcuatus*" is given considerable latitude by these authors and seems to agree in most particulars with the forms under consideration.

Occurrence.—Common in "Blue Earth" beds of the Oneota at Mankato, Minn.; the Oneota near Marquette, Iowa; and the Shakopee near Clyde and Ripon, Wis.; and Lanesboro and Shakopee, Minn.

Syntypes.—State Univ. Iowa, nos. 1278–1289.

DREPANODUS TORTUS Furnish, n. sp.
Plate 42, figure 6

A typical representative of the genus which is associated with *D. subarcuatus* and is closely related to that species. Cusp nearly straight; base moderately expanded; keels appear well above base of cusp; cross section of cusp subcircular at base, but compressed laterally above strong basal flexure.

Remarks.—Distinguishing features are the relatively short cusp and the marked twist of cusp relative to base. Further study may show that this form is but an aberrant representative of *D. subarcuatus*, but at present it seems better to recognize it as a distinct species.

Occurrence.—Rare in Shakopee near Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1290, 1291.

Genus OISTODUS Pander, 1856

Numerous Ordovician species have been referred to this genus, which Pander diagnosed as possessing a "sehr breiten und langen, hohlen Basis." The genotype has a particularly large base. The general concept is in agreement with Pander's original interpretation, but most of the species of *Oistodus* that have been described are simple representatives. The genus ranges throughout the Ordovician and it is often abundant in strata of this age. Several Lower Ordovician species of *Oistodus* have closely related counterparts in the Middle Ordovician, some of which may be conspecific.

Genotype: *Oistodus lanceolatus* Pander.

OISTODUS CONCAVUS
Branson and Mehl
Plate 41, figures 16, 17

Oistodus concavus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 59, pl. 4, fig. 6.

Base distinctly set off from cusp and greatly expanded laterally; basal cavity very shallow but growth axis not visible; cusp evenly rounded in normal manner and with slight lateral curvature as well, flattened laterally and keeled anteriorly and posteriorly.

Occurrence.—Originally, this species was described from the "Jefferson City" dolomite. In the Upper Mississippi Valley it occurs rarely in the Shakopee formation near Clyde, Wis., and in the "Blue Earth" beds at Mankato, Minn.

Hypotypes.—State Univ. Iowa, nos. 1292, 1293.

OISTODUS ERECTUS Furnish, n. sp.
Plate 42, figure 4

Simple forms with straight flattened cusps; base moderately expanded, primarily in a lateral direction, but some individuals show greater anteroposterior expansion of the base than in the figured specimen. Average specimens have less curvature, and some "Blue Earth" specimens are more compressed laterally.

Remarks.—Expanded base and bladelike cusp are characteristic of the genus.

The general lack of curvature distinguishes this form from other species.

Occurrence.—Rare in the "Blue Earth" at Mankato, Minn.; the Oneota at Lanesboro, Minn., and Marquette, Iowa; and in the Shakopee near Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1294–1298.

OISTODUS INCLINATUS Branson and Mehl
Plate 41, figure 18

Oistodus inclinatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 110, pl. 9, fig. 8.—STAUFFER, *1935*, Geol. Soc. America, Bull., vol. 46, p. 147, pl. 12, fig. 21; *1935*, Jour. Paleontology, vol. 9, pp. 610, 611, pl. 74, fig. 41; pl. 75, figs. 9, 14.

This form is hesitantly identified with a Middle Ordovician species, since no other conodont is known to have persisted into this series from the Lower Ordovician. No evident differences seem to exist, however. The flat straight cusp, sharply recurved at the base, is a distinctive character of the species.

Occurrence.—Rare in "Blue Earth" at Mankato, Minn.; in the Oneota near Lanesboro, Minn.; and the Shakopee near Clyde, Wis.

Hypotypes.—State Univ. Iowa, nos. 1299–1302.

OISTODUS MEHLI Furnish, n. sp.
Plate 42, figures 7, 8

Cusp somewhat compressed laterally, possessing anterior and posterior keels; anterior keel particularly well developed, extending downward to form a prolongation of the anterior basal margin below the general plane of the base. Base extended laterally and posteriorly to give a nearly circular outline. Basal cavity fairly shallow, but growth axis is not perceptible in any of the syntypes.

Occurrence.—This species apparently represents a stable unit of the "Blue Earth" fauna from Mankato, Minn., where it is common. The few representatives collected from the Oneota near Marquette, Iowa, are somewhat variable and not so distinctive in appearance.

Syntypes.—State Univ. Iowa, nos. 1303–1306.

OISTODUS PANDUS Branson and Mehl
Plate 42, figure 5

Oistodus pandus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 61, pl. 4, figs. 21, 22.

The forms from the Prairie du Chien referred to this species are very similar to the types from Missouri. Characteristic features are the strongly curved, bladelike cusp, and the large laterally compressed base. Some of the individuals show the anterior keel-like edge mentioned by Branson and Mehl, although this is not developed on the figured specimen. This species resembles the related species, *Drepanodus subarcuatus*, with which it occurs, and it probably is congeneric with the form described by Branson and Mehl as *Cordylodus simplex*. Structurally, these forms differ very little from typical representatives of *Acanthodus* described below.

Occurrence.—A few rather fragmentary specimens from the Shakopee near Clyde, Wis., seem to represent this species. Well-preserved individuals occur rarely in the "Blue Earth" at Mankato, Minn.

Hypotypes.—State Univ. Iowa, nos. 1307–1309.

OISTODUS? TRIANGULARIS
Furnish, n. sp.
Plate 42, figure 22

Cusp slightly and evenly curved; base not greatly enlarged or prominently set off from cusp, and basal cavity only moderately deep. The tooth is keeled posteriorly and flattened laterally and anteriorly. One anterolateral corner is sharply keeled and flanked posteriorly by a groove; the other side is only narrowly rounded—of course, this relationship is merely reversed in dextral and sinistral teeth. A cross section at mid-height of cusp is triangular in shape, but the anterior side is much shorter than the flanks. A fundamental asymmetry is demonstrated by the basal cavity, which lies predominantly on the side opposite the strong lateral keel. The

cross section of this species is rather unique.

Occurrence.—Common in "Blue Earth" at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1310, 1311.

Genus PALTODUS Pander, 1856

Forms described by Pander under this name closely resemble representatives of *Scolopodus* but differ in that the cross section of the cusp is strongly asymmetrical. Base and basal cavity are moderate in size; cusp is slightly curved and grooved laterally. Three species occur in the "Jefferson City" of Missouri and six species were described by Pander. The numerous species referred to this genus which occur in strata younger than Lower Ordovician should probably be regarded as generically distinct.

Genotype: *Paltodus subaequalis* Pander.

PALTODUS BASSLERI Furnish, n. sp.
Plate 42, figure 1

Cusp broadly rounded anteriorly, deeply grooved laterally and narrowly rounded posteriorly; curvature greatest just above base, so that major portion of cusp is nearly straight. Base appreciably expanded posteriorly and moderately well set off from cusp.

Remarks.—The cross section of *P. bassleri*, which is almost bilaterally symmetrical and flattened anteriorly, may indicate that this form should be referred to some other genus than *Paltodus*. However, the close relationship between this species and *P. variabilis*, a more nearly typical representative of the genus described below, is certainly of generic importance.

Occurrence.—Common in the "Blue Earth" beds at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1312, 1313.

PALTODUS VARIABILIS Furnish, n. sp.
Plate 42, figures 9, 10

Rounded asymmetrical cusp grades into base without decided line of junction. Curvature uniformly slight and in lower portion of tooth. Cross section rounded but indented by a prominent lateral and a posterolateral groove. Growth axis not observed, but basal cavity moderate in size with apex near the anterior margin.

Remarks.—This abundant species is a major constituent of all Oneota faunas examined, and, therefore, may be regarded as diagnostic of this horizon. As is to be expected, the numerous specimens show considerable variation, but the differences are gradational and can scarcely be divided into groups. This species may be distinguished from *P. bassleri*, with which it is associated, by the relatively slight amount of flexure and the shape of the cross section. Neither of the species described by Branson and Mehl from Missouri appears to be closely related.

Occurrence.—Common in the "Blue Earth" and Oneota at Mankato, Minn., and the Oneota near Lanesboro, Minn., and Marquette, Iowa.

Syntypes.—State Univ. Iowa, nos. 1314–1319.

Genus SCOLOPODUS Pander, 1856

This genus was originally used by Pander to include simple cones only slightly expanded at the base and ellipsoidal in cross section. Cusp is typically marked by lateral and posterior grooves or costae. Part of Pander's generic diagnosis can be translated to read: "Slender teeth of variable shape, rounded anteriorly and posteriorly and with convex more or less ribbed surfaces." The genotype, *S. sublaevis*, is fairly representative of the group originally referred to this genus.

Pander has described six species from the Lower Ordovician of the Baltic region, and Branson and Mehl have described four additional species from the Lower Ordovician of Missouri. The occurrence of congeneric forms in younger strata has not been demonstrated—Carboniferous teeth referred to the genus do not appear to be closely related. The

genus *Scolopodus* occurs in both the Oneota and Shakopee formations of the Upper Mississippi Valley. One species, *S. quadraplicatus*, has been found in all Shakopee faunas examined, although what appear to be conspecific forms were collected from one Oneota locality as well.

Genotype: *Scolopodus sublaevis* Pander.

Scolopodus quadraplicatus
Branson and Mehl
Plate 41, figures 1–12

Scolopodus quadraplicatus Branson and Mehl, *1933*, Missouri Univ. Studies, vol, 8, p. 63, pl. 4, figs. 14, 15.

This form is one of the most abundant species in the Shakopee conodont fauna and occurs at several localities in relative abundance. There is considerable variation in curvature, expansion of base, and rate of expansion of cusp, but all such variation seems to be gradational and not of specific rank. The species is here defined to include forms in which the lateral groove is but poorly developed on one side. This character is typical of small specimens and common in normal-sized individuals. No specimens were noted with a slight posterior median keel, described by Branson and Mehl as a possible variant in this species. In most cases cusp is conspicuously asymmetrical and base is aligned to right or left of axial plane of cusp.

Occurrence.—This species was originally described from "Jefferson City" dolomite of central Missouri. In the Upper Mississippi Valley it occurs at approximately the same horizon in Shakopee formation at Clyde and Ripon, Wis.; Lanesboro and Shakopee, Minn.; and in upper Oneota at Marquette, Iowa.

Hypotypes.—State Univ. Iowa, nos. 1320–1330.

Scolopodus shakopeensis
Furnish, n. sp.
Plate 41, figure 13

This species is characterized by a straight moderately tapering bilaterally symmetrical cusp, recurved and expanded at the base. The cusp is rounded in cross section, but has distinct lateral grooves and an indistinct posterior groove. Basal cavity is shallow and growth axis is straight.

Remarks.—In many respects this species resembles *Ulrichodina? deflexus* very closely, but the anterior portion of the base is not depressed as in that form. The relatively short cusp and expanded base serve to distinguish this form from *S.*

Explanation of Text Figure 1

Fig. 1.—Diagrammatic longitudinal and cross sections of representative Prairie du Chien distacodid conodonts, showing the general outline of the tooth, the shape of the basal cavity, and the position of the growth axis:

A, *Ulrichodina prima* Furnish, n. sp., ×65—same specimen as pl. 41, figs. 21, 22.
B, *Ulrichodina wisconsinensis* Furnish, n. sp., ×65—pl. 41, figs. 19, 20.
C, *Ulrichodina? deflexus* Furnish, n. sp., ×65—pl. 41, figs. 23, 24.
D, *Clavohamulus densus* Furnish, n. sp., ×55—pl. 42, figs. 18, 19.
E, *Paltodus variabilis* Furnish, n. sp., ×45—pl. 42, fig. 9.
F, *Drepanodus subarcuatus* Furnish, n. sp., ×45—pl. 41, fig. 29. (The cusp of this specimen has been regenerated.)
G, *Drepanodus subarcuatus* Furnish, n. sp., ×45—pl. 41, fig. 30.
H, *Drepanodus lineatus* Furnish, n. sp., ×30—pl. 41, fig. 33.
I, *Scolopodus sulcatus* Furnish, n. sp., ×45—pl. 41, figs. 14, 15.
J, *Scolopodus quadraplicatus* Branson and Mehl, ×65—pl. 41, fig. 12.
K, *Acontiodus staufferi* Furnish, n. sp., ×55—pl. 42, fig. 11.
L, *Acontiodus iowensis* Furnish, n. sp., ×55—pl. 42, figs. 16, 17.
M, *Acontiodus propinquus* Furnish, n. sp., ×65—pl. 42, figs. 13, 14.
N, *Acodus oneotensis* Furnish, n. sp., ×45—pl. 42, fig. 28.
O, *Distacodus? simplex* Furnish, n. sp., ×65—pl. 42, fig. 25.
P, *Oistodus? triangularis* Furnish, n. sp., ×45—pl. 42, fig. 22.
(*C*, *E*, *H*, *I*, *L*, *M*, *N*, *O*, and *P* are in part reconstructions.)

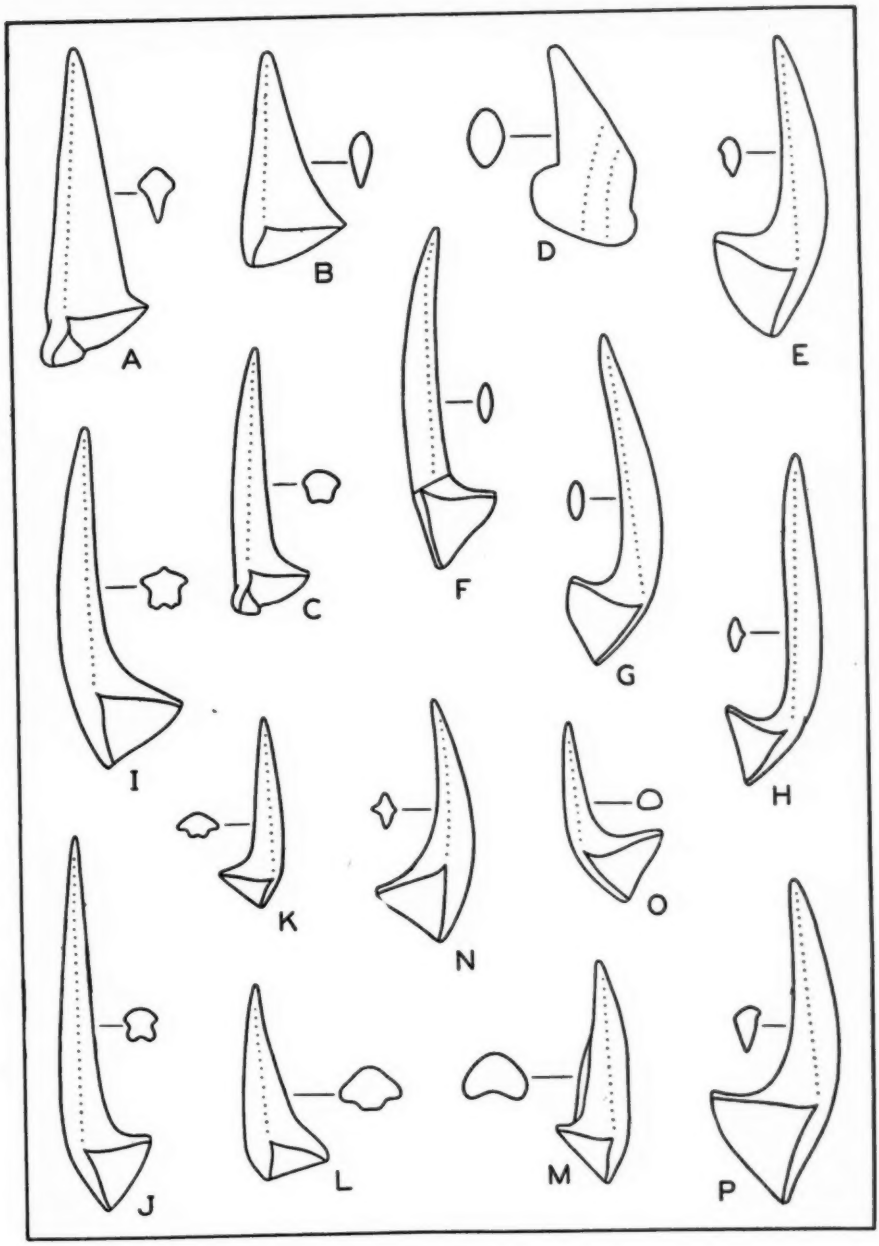

FIG. 1

quadraplicatus with which it is associated.

Occurrence.—Rare in Shakopee near Lanesboro, Minn., and Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1331–1333.

SCOLOPODUS SULCATUS Furnish, n. sp.
Plate 41, figures 14, 15

Only a single species of this genus has been found in the lower Oneota. Base asymmetrical and distinctly set off, but not greatly expanded. Cusp approaches bilateral symmetry, moderately curved through the basal half so that the basal plane is inclined at a high angle to axis. Basal cavity moderately deep and conical in shape; growth axis not visible in any of the syntypes. There is considerable range in size and some variation in details of ornamentation. Typically the anterior side is flattened and marked by a fine median carina. Anterolateral extremities are angular in shape and flanked posteriorly by deep lateral grooves. Posterolateral portions are somewhat rounded and may be incipiently bifid. Posterior groove is generally not as well developed as the lateral grooves. Some individuals illustrate marked variation in cross section of cusp. Although a four-sided outline is retained, fine carinae are introduced laterally or posteriorly, or both. In contrast, simple variants show a resemblance to *Acodus oneotensis.*

Occurrence.—Rare in the "Blue Earth" beds at the base of the Oneota formation in Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1334, 1335.

Genus ULRICHODINA
Furnish, n. gen.

The Shakopee collections contain a number of forms which are quite different from all genera previously described. Typically, these forms are bilaterally symmetrical and possess a laterally compressed straight cusp rapidly expanding in an anteroposterior direction. The lateral dimension is greatest near the anterior margin, which is rounded; the posterior margin is keel-like. Basal cavity is shallow, the base slightly flared laterally and extending downward an-

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EXPLANATION OF PLATE 41

All specimens are from the Lower Ordovician Prairie du Chien beds of the Upper Mississippi Valley, and all figures are magnified ×45.

FIGS. *1–12—Scolopodus quadraplicatus* Branson and Mehl. *1, 2,* Oneota formation near Marquette, Iowa; *3, 4,* Shakopee formation at Shakopee, Minn.; *5–7,* Shakopee formation at Ripon, Wis.; *8, 9,* Shakopee formation near Lanesboro, Minn.; *10–12,* Shakopee formation near Clyde, Wis. (p. 332)

13—Scolopodus shakopeensis Furnish, n. sp. Shakopee formation near Clyde, Wis. (p. 332)

14, 15—Scolopodus sulcatus Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 334)

16, 17—Oistodus concavus Branson and Mehl. *16,* Shakopee formation near Clyde, Wis.; *17,* Oneota formation at Mankato, Minn. (p. 329)

18—Oistodus inclinatus Branson and Mehl. Shakopee formation near Clyde, Wis. (p. 330)

19, 20—Ulrichodina wisconsinensis Furnish, n. sp. Shakopee formation near Clyde, Wis. (p. 336)

21, 22—Ulrichodina prima Furnish, n. sp. Shakopee formation near Clyde, Wis. (p. 335)

23, 24—Ulrichodina? deflexus Furnish, n. sp. Shakopee formation near Lanesboro, Minn. (p. 335)

25–32—Drepanodus subarcuatus Furnish, n. sp. *25, 26,* Shakopee formation near Lanesboro, Minn.; *27,* Shakopee formation at Shakopee, Minn.; *28–30,* Shakopee formation near Clyde, Wis.; *31, 32,* Oneota formation near Marquette, Iowa. (See pl. 42, figs. 2 and 3.) (p. 328)

33, 34—Drepanodus lineatus Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 328)

Furnish, Lower Ordovician Conodonts

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teriorly, but the anterior extension may be depressed posteriorly. Anterior depression may possibly have served to accommodate another tooth set directly in front of it

Numerous representatives of this form, here named *Ulrichodina*, have been found in the Shakopee dolomite of southwestern Wisconsin, and a single species has been found in this formation in Minnesota. The "Jefferson City" fauna also contains one representative, *U. abnormalis* (Branson and Mehl). *Distacodus dilatatus* (Pander) and *D. inaequalis* (Pander) seem to represent a closely related group of species but differ in several structural features.

Genotype: *Ulrichodina prima* Furnish, n. sp.

ULRICHODINA PRIMA Furnish, n. sp.
Plate 41, figures 21, 22

Teeth bilaterally symmetrical, which consist of a laterally compressed cusp and a slightly flared base. The cusp has a rounded or flattened anterior margin and a sharp keel-like posterior margin. Flattened sides are marked by concavities that are nearly parallel to anterior margin and a groove may also be present on anterolateral portions of large specimens. Lower portion of cusp often marked by numerous indistinct longitudinal striations; base distinctly flared laterally and to a lesser extent posteriorly; anterior basal extension prominently depressed posteriorly, making the basal outline heart-shaped; basal cavity very shallow but acuminate at the apex. Growth axis essentially straight, extending from apex of basal cavity to point of cusp. Plane of the base slightly inclined to normal of the growth axis. Diagnostic features appear early during ontogenetic development and are merely accentuated in larger specimens.

Remarks.—The depressed antero-basal extension characteristic of this species is known to occur elsewhere in only *Ulrichodina? deflexus;* the general form is otherwise very close to *U. abnormalis.*

Occurrence.—Moderately common in Shakopee dolomite near Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1336, 1337.

ULRICHODINA WISCONSINENSIS
Furnish, n. sp.
Plate 41, figures 19, 20

This species occurs in association with *U. prima* and is closely related to it. Cusp laterally compressed and rapidly expanded anteroposteriorly. Posterior margin sharp and keel-like, but anterior margin narrowly rounded. Greatest lateral dimension follows growth axis and parallels anterior margin. Lateral portions of cusp essentially smooth and evenly rounded. Base expanded, flared laterally, and more or less extended downward anteriorly. Anterior portion of base distinctly recurved posteriorly in most specimens, but not depressed. Shallow basal cavity attenuate and recurved apically; growth axis readily perceptible as a straight line extending from the apex of the basal cavity to the point of the tooth.

Remarks.—This species is easily distinguished from *U. prima*, described above, by its evenly rounded sides and its straight antero-basal extension. Rate of anteroposterior expansion is greater in this species than in *U. prima*, and although this character is somewhat variable, the figured specimen is a typical representative.

Occurrence.—Moderately common in Shakopee dolomite near Clyde, Wis.

Syntypes.—State Univ. Iowa, nos. 1338, 1339.

ULRICHODINA? DEFLEXUS
Furnish, n. sp.
Plate 41, figures 23, 24

This species has a nearly straight symmetrical cusp, rounded in cross section but with distinct lateral grooves. Base only slightly expanded laterally and recurved posteriorly; anterior portion of base depressed posteriorly, much as in *U. prima*. Basal cavity shallow and growth axis straight.

Remarks.—The depressed anterior margin serves to establish relationship of this species with *Ulrichodina*, but the rounded cross section may be sufficient to differentiate it generically. Holotype and only known representative is well preserved and nearly complete; missing tip portion represents less than one-third of total original length.

Occurrence.—Shakopee dolomite near Lanesboro, Minn.

Holotype.—State Univ. Iowa, no. 1340.

Genus ACANTHODUS Furnish, n. gen.

Very few conodont genera may be recognized as intermediate between simple and compound teeth; this genus, however, is clearly of a transitional type. Small denticles, which are characteristic of the genus, apparently do not appear until a moderate size has been reached. In general form, this genus resembles certain simple representatives of the genus *Oistodus* such as *O. pandus;* the denticulate posterior margin of cusp is the only means of distinction. There is question if this genus gave rise to more advanced forms, for denticles which are inclined toward base are unique. There is a superficial resemblance between *Acanthodus* and Middle and Upper Ordovician forms of the Mississippi Valley referred to *Belodus*. However, denticles in the latter are essentially normal to the axis of the bar rather than inclined to it and the two units arose from altogether different stocks. Representatives of *Acanthodus* have been found in only the Lower Ordovician Oneota dolomite at Mankato, Minn.

EXPLANATION OF PLATE 42

All specimens are from the Lower Ordovician Prairie du Chien beds of the Upper Mississippi Valley, and all figures are magnified ×45.

FIG. *1—Paltodus bassleri* Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 331)

2, 3—Drepanodus subarcuatus Furnish, n. sp. *2*, Shakopee formation at Ripon, Wis.; *3*, Shakopee formation near Clyde, Wis. (See pl. 41, figs. 25–32.) (p. 328)

4—Oistodus erectus Furnish, n. sp. Oneota formation near Marquette, Iowa. (p. 329)

5—Oistodus pandus Branson and Mehl. Oneota formation at Mankato, Minn. (p. 330)

6—Drepanodus tortus Furnish, n. sp. Shakopee formation near Clyde, Wis. (p. 329)

7, 8—Oistodus mehli Furnish, n. sp. *7*, Oneota formation at Mankato, Minn.; *8*, Oneota formation near Marquette, Iowa. (p. 330)

9, 10—Paltodus variabilis Furnish, n. sp. *9*, Oneota formation at Mankato, Minn.; *10*, Oneota formation near Marquette, Iowa. (p. 331)

11, 12—Acontiodus staufferi Furnish, n. sp. Shakopee formation near Clyde, Wis. (p. 326)

13–15—Acontiodus propinquus Furnish, n. sp. Oneota formation at Mankota, Minn. (p. 326)

16, 17—Acontiodus iowensis Furnish, n. sp. Oneota formation near Marquette, Iowa. (p. 325)

18–21—Clavohamulus densus Furnish, n. sp. *18–20*, Oneota formation near Marquette, Iowa; *21*, Oneota formation near Lanesboro, Minn. (p. 327)

22—Oistodus? triangularis Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 330)

23—Distacodus? gracilis Furnish, n. sp. Shakopee formation at Ripon, Wis. (p. 327)

24, 25—Distacodus? simplex Furnish, n. sp. Oneota formation near Marquette, Iowa. (p. 328)

26–29—Acodus oneotensis Furnish, n. sp. *26*, Oneota formation near Marquette, Iowa; *27*, Oneota formation near Lanesboro, Minn.; *28, 29*, Oneota formation at Mankato, Minn. (p. 325)

30—Acanthodus uncinatus Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 337)

31—Cordylodus intermedius Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 338)

32—Cordylodus subangulatus Furnish, n. sp. Oneota formation at Mankato, Minn. (p. 338)

33, 34—Loxodus bransoni Furnish, n. sp. Oneota formation near Marquette, Iowa. (p. 339)

Furnish, Lower Ordovician Conodonts

UNIV. OF MICH.

Genotype: *Acanthodus uncinatus* Furnish, n. sp.

ACANTHODUS UNCINATUS
Furnish, n. sp.
Plate 42, figure 30

Teeth typical distacodid, which have developed a row of small denticles on posterior keel of cusp. A moderate flexure occurs above the slightly enlarged base. Cusp compressed laterally and marked by inclined denticles. Basal cavity conical, with apex nearer anterior margin than posterior. Growth axis poorly shown by the syntypes but appears to be straight and to have projections corresponding to the posterior denticles. All of syntypes are moderately large; smaller specimens may not show denticles. The prominence of the denticulations shows some variation within the species.

Occurrence.—Rare in the "Blue Earth" beds and the Oneota dolomite at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1341–1343.

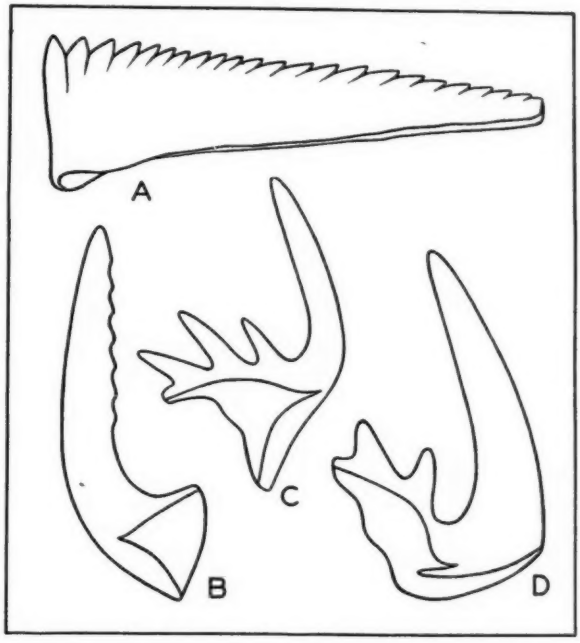

FIG. 2.—Diagrammatic representations of the compound conodonts known from the Prairie du Chien:
A, *Loxodus bransoni* Furnish, n. sp., ×55.
B, *Acanthodus uncinatus* Furnish, n. sp., ×30—based primarily on pl. 42, fig. 30.
C, *Cordylodus intermedius* Furnish, n. sp., ×55—pl. 42, fig. 31.
D, *Cordylodus subangulatus* Furnish, n. sp., ×55—pl. 42, fig. 32.

Genus CORDYLODUS Pander, 1856

Two species from the Prairie du Chien described below appear to be the first typical representatives of the genus described since Pander established the name for forms from the Baltic Lower Ordovician. The genotype, *C. angulatus*, is clearly a primitive type of compound tooth and appears to have but three to five small denticles. This genus is characterized by forms with a prominent

anterior cusp and a short denticulate bar. Base not greatly expanded, for the anterior margin recedes backward beneath the bar and there is a deep attenuate basal cavity.

As the genus is now restricted, it is known from only the Lower Ordovician. Middle Ordovician forms referred to this genus are now regarded as belonging in *Subcordylodus*, *Plectodina*, and related genera. While these advanced types resemble typical *Cordylodus* and probably are closely related, they should nevertheless be regarded as generically distinct. The species from the Lower Ordovician of Missouri described by Branson and Mehl as *C. simplex* does not possess a denticulate bar, and should, therefore, be placed in some other genus. "*C.*" *simplex* seems to be closely related to forms here included in *Oistodus*, but may have given rise to forms like *Cordylodus*.

The two species described by Pander differ fundamentally in that the one, *C. rotundatus*, has the cusp and bar well set off from each other, whereas in *C. angulatus* there is little differentiation of the two parts. Also the basal cavity in the first extends all along the aboral surface, but in the latter it is restricted to a posterior position. The two species described below are likewise divisible into similar units, each of which is very closely related to the forms described by Pander.

Genotype: *Cordylodus angulatus* Pander.

Cordylodus intermedius
Furnish, n. sp.
Plate 42, figure 31

Teeth compound, with prominent anterior cusp and short arched denticulate bar. Denticles relatively large, discrete, inclined, and slightly flattened laterally. Axis of cusp normal to bar, edged anteriorly and posteriorly, and slightly twisted. Sides broad and flat, enclosing large basal cavity which is attenuate and recurved anteriorly to bring the apex near the anterior margin. Growth axes not discernible.

Remarks.—The figured syntype is essentially complete posteriorly and probably had only three denticles on the bar. Smaller but complete syntypes have only a single denticle. There is considerable variation in the forms referred to *C. angulatus* by Pander. Typically, however, it is almost identical with *C. intermedius*, although the latter species appears to be somewhat more primitive. Structurally, these species are much like Middle Ordovician forms and quite certainly they represent a major evolutionary trend.

Occurrence.—Rare in the "Blue Earth" beds at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1344, 1345.

Cordylodus subangulatus
Furnish, n. sp.
Plate 42, figure 32

Another very primitive type of compound tooth was found which clearly retains major features of its distacodid ancestor. Strong cusp slightly curved and laterally compressed. Base recurved and moderately expanded. Relatively shallow basal cavity extends as a narrow opening to anterior border. Cylindrical denticles small and inclined to bar; they may be one or two in number.

Remarks.—No distacodid teeth were found in the Prairie du Chien beds which appear to be particularly close to *C. subangulatus*, but *Oistodus lanceolatus*, the genotype of *Oistodus*, seems to be near the non-denticulate ancestor of the species under consideration. *C. rotundatus* Pander is very similar to *C. subangulatus*, but is a somewhat more advanced type.

Occurrence.—Rare in the "Blue Earth" beds at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1346, 1347.

Genus Loxodus Furnish, n. gen.

This unique form, which occurs in the Oneota formation, is apparently a rather advanced type, for it shows no obvious relationships with distacodids. It is like-

wise quite distinct from all genera of compound teeth known from younger strata and may not have given rise to subsequent groups.

In this genus denticles become progressively inclined to the axis of the tooth posteriorly. Growth lamellae indicate that denticles are added posteriorly during growth of tooth; this observation likewise established by specimens of variable size. Narrow basal cavity extends lengthwise and is but slightly expanded beneath anterior denticle. External form of this genus superficially resembles many polychaeta jaws, but the internal structure and phosphatic composition signify that it is a typical conodont. The lack of a prominent cusp on the bar and the inclined confluent denticles serve to distinguish this form from most described genera. *Coleodus* appears to be closely related, but has an expanded base quite different from *Loxodus*. There is little resemblance to the common Middle Ordovician chirognathid type of conodont, which has only a few elongate curved denticles.

Genotype: *Loxodus bransoni*, n. sp.

LOXODUS BRANSONI Furnish, n. sp.
Plate 42, figures 33, 34

Flat denticulate teeth consisting of a broad bar and numerous flat confluent denticles. Anterior denticle normal to axis of tooth; succeeding denticles progressively inclined to axis without regular gradation in size, for the crowded anterior portion may have smaller denticles than posterior. Denticles are added with growth; individuals of moderate size have about 20. Basal cavity narrow but relatively deep. Both oral and basal outlines essentially straight; height of tooth diminishes uniformly towards posterior. Apparently there is an increase in relative length during growth of tooth. Some few specimens show irregularities in general outline, but these all appear to be due to individual differences.

Occurrence.—Compound teeth are exceedingly rare in Prairie du Chien faunas, as a general rule, but this distinctive species occurs commonly in the Oneota near Marquette, Iowa. A single specimen has been found in the "Blue Earth" beds of this formation at Mankato, Minn.

Syntypes.—State Univ. Iowa, nos. 1348–1350.

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W. M. FURNISH, STATE UNIVERSITY OF IOWA, IOWA CITY, IOWA. MANUSCRIPT RECEIVED BY THE EDITOR, MARCH 10, 1938.

JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 4, PP. 341–374, PLS. 43, 44, 4 TEXT FIGS., JULY, 1938

CEPHALOPODS FROM THE CARBONIFEROUS MORROW GROUP OF NORTHERN ARKANSAS AND OKLAHOMA

A. K. MILLER AND CARL A. MOORE

ABSTRACT

Recent collecting in the Hale formation of the Morrow group near Harrison, Ark., has yielded representatives of the following cephalopod genera: *Pseudorthoceras*, *Mooreoceras*, *Coloceras*, *Bactrites*, *Pronorites*, *Cravenoceras?*, *Brannerоceras*, *Glaphyrites*, and *Bisatoceras*. These and the few forms previously described from the Morrow are illustrated and discussed in detail. Of the latter, *Gastrioceras kesslerense* Mather is referred to *Phaneroceras* and *G. branneri* Smith is now the genotype of *Brannerоceras;* the precise affinities of *Gastrioceras pygmaeum* Mather, however, can not be determined as it is based on immature specimens. The conclusion is reached that though the Morrow cephalopods are related to both Mississippian and Pennsylvanian forms, they are more like the latter than the former.

In northern Arkansas and northeastern Oklahoma, on the southwestern flank of the Ozarks, the beds of sandstone, shale, and limestone that occur between the Pitkin limestone (upper Mississippian) and the Atoka (†Winslow) sandstone (lower Pennsylvanian) are collectively known as the Morrow group. Strata that are believed to be the approximate stratigraphic equivalents of these northern Arkansas-Oklahoma beds outcrop in the Arbuckle region of southern Oklahoma, in the Llano region of central Texas, in southern Illinois, and in central Alabama.

The Morrow varies greatly in thickness over its large area of outcrop, but typically it totals several hundred feet. Equivalent beds in southern Oklahoma, near Ardmore, are as much as 4,000 feet thick. In the type area, which is near Morrow, Ark., close to the Oklahoma boundary, the group is divisible into the Hale formation below and the Bloyd shale above; in addition, two limestone members or lentils of the Bloyd are recognized, the Brentwood and the Kessler limestones. To the west, in Oklahoma, the Morrow becomes more calcareous and there it is called a formation; nevertheless, in eastern Oklahoma the Hale sandstone member at the base is still recognizable.

In northern Arkansas and Oklahoma the Morrow rests unconformably on the Pitkin limestone or the underlying Fayetteville shale, both of which are upper Mississippian in age, and it is overlain unconformably by the Atoka sandstone, which is Des Moines (lower Pennsylvanian) in age. In some places the unconformity between the Morrow and the succeeding beds is very conspicuous. Locally in central Texas, beds that are equivalent to the Morrow overlap onto Lower Ordovician strata.

The Morrow is abundantly fossiliferous, and the fossils it has yielded have attracted considerable interest, for they consist of intermingled Mississippian and Pennsylvanian types. Because of the equivocal nature of its fossils and because it lies unconformably between typical Mississippian and typical Pennsylvanian strata, the age of the Morrow has long been a moot question. Most of the early paleontologists regarded the Morrow fauna as Mississippian in age, whereas the contemporary paleobotanists recognized the affinities of the Morrow flora with those of the lower Pennsylvanian. Shortly after the beginning of the present century, both Ulrich and Girty concluded that the Morrow fauna, like the flora, is indicative of a lower Pennsylvanian age, and Mather's study (1915) of the fauna tended to confirm this conclusion.

Also, Croneis (1930) in his report on the *Geology of the Arkansas Paleozoic area* assigned the Morrow unequivocally to the Pennsylvanian. In 1934 (p. 452) and in 1936 (p. 603) Moore placed the Morrow in the Mississippian; nevertheless, in a footnote added to the earlier of these publications he stated that his most recent studies had led him to the conclusion that the "preponderance of evidence favors classification of the Morrow and equivalent beds as Pennsylvanian," and apparently he (1938) is still of this opinion. Harlton (1934) has gone so far as to propose the establishment of a new system, the Bendian, intermediate between the Mississippian and Pennsylvanian, for the Morrow and its affines.

Our study of the Morrow cephalopods of northern Arkansas and Oklahoma has not tended to clarify this problem as much as had been hoped. Nevertheless, it can be said definitely that the cephalopods, though related to both Mississippian and Pennsylvanian forms, are more like the latter than the former. Several of the genera represented, e.g., *Pronorites* and *Coloceras*, were originally described from the Lower Carboniferous, but Upper Carboniferous representatives of them have since been found. Most of the other genera are typical of the Pennsylvanian and they are not known to be represented in lower strata.

The literature contains very little information in regard to Morrow cephalopods. However, in 1896 J. P. Smith described two ammonoids, *Pronorites arkansasensis* and *Branneroceras branneri*, from Pilot Mountain in Carroll County, Ark. Originally, Smith stated that the strata from which these ammonoids came were part of the "Lower Coal Measures," but in 1903 he referred to them as the "upper part of the St. Louis-Chester" group. It is clear from a comparison of Smith's stratigraphic notes of 1896 (pp. 219, 258, and 270) and 1903 (p. 46) with the sections published by Williams in 1900 (p. 359) and Purdue and Miser in 1916 (p. 22) that, as Mather (1915, p. 242) has pointed out, the specimens studied by Smith came from the Morrow; that is, they came from the Hale formation. Lithologically, they are strikingly similar to the conspecific specimens we have from a limestone lens in the Hale on Gaither Mountain, which is only about 10 miles from the locality that yielded Smith's specimens. Mather (1915, pp. 241–244) also recorded the occurrence of *Branneroceras branneri* in the Hale at Fayetteville, Ark., and in the Morrow near Ft. Gibson, Okla.; and he described *Phaneroceras kesslerense* from the Kessler limestone member of the Bloyd shale (upper Morrow) at Fayetteville and the Morrow near Choteau, Okla., and *"Gastrioceras" pygmaeum* from the Brentwood limestone member of the Bloyd near Fayetteville and the Morrow near Wagoner, Okla. Also, he described as *"Orthoceras* sp." some fragmentary orthoconic nautiloids from the Brentwood near Fayetteville and the Morrow near Ft. Gibson—presumably these specimens represent *Mooreoceras* and *Pseudorthoceras*, or both. Finally, Purdue and Miser (1916, pp. 14, 15) listed *Pseudorthoceras knoxense?*, *Endolobus?* sp., and *Gastrioceras* 4 sp. from the Hale, *Endolobus* sp. and *Gastrioceras* sp. from the Brentwood, and *Orthoceras* sp. from the Kessler. We have not seen the specimens on which these lists were based.

The majority of the fossils described in the present report came from a limestone lens in the Hale formation of the Morrow group. They were collected by the junior author during the summer of 1937 on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.). Additional material from this locality was loaned for study by Drs. L. R. Laudon and L. M. Cline, and Dr. Laudon called our attention to the outcrop. Also, Prof. Carey Croneis made available for study the type specimens of the Morrow cephalopods in Walker Museum of the University of Chicago,

and Dr. G. A. Cooper supplied photographs of the types in the U. S. National Museum. Acknowledgment is also due to Dr. G. H. Girty for his courteous attitude on publication of this study ahead of a comprehensive report on the Morrow fauna on which he has been working for some years and which is now nearing completion. The photographs of the fossils were retouched by Mr. Howard Webster, and Dr. W. M. Furnish helped with the preparation of these photographs and the diagrammatic representations of the sutures.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDORTHOCERAS Girty, 1911

PSEUDORTHOCERAS KNOXENSE (McChesney)

Plate 43, figure 4

Miller, Dunbar and Condra (1933, pp. 81–85) recently described this species in detail and listed its complete synonymy. It will suffice here to state that our collections from the Morrow contain one specimen in which the preserved portion of the conch is straight, circular in cross section, and smooth; the sutures are straight and, being directly transverse to the long axis of the conch, form simple circles; and the siphuncle is central in position. Since we have only one representative of this species, we have not made a section of it, but a transverse break in the specimen reveals structures that appear to represent the intracameral deposits that are so characteristic of *Pseudorthoceras*. The specimen under consideration is about 47 mm long, but it is not complete adorally or adapically and is septate throughout. Near its adoral end it attains a maximum diameter of about 9 mm.

Occurrence.—The specimen came from a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.). As is well known, this species is widely distributed in the Pennsylvanian of North America, and it has been reported also from the Upper Carboniferous of Europe (Carnic Alps). Stratigraphically, it ranges essentially throughout the Pennsylvanian rocks of North America.

Figured specimen.—State Univ. Iowa, no. 1988.

Genus MOOREOCERAS
Miller, Dunbar, and Condra, 1933

MOOREOCERAS NORMALE?
Miller, Dunbar, and Condra

We have about 35 specimens that we are tentatively referring to this species. All of them are small and fragmentary, and it is not possible to determine with certainty their specific affinities; therefore, we are not illustrating any of them. Only the chambered portion of the conch, the phragmacone, is represented, and none of the specimens is complete adorally or adapically. All of the specimens are straight, and circular or subcircular in cross section. The longest of them is only about 32 mm in length, and the largest attains a maximum diameter of only about 9 mm. Test thin and smooth. Sutures straight and directly transverse to long axis of the conch. Siphuncle small, subcentral in position, but located distinctly nearer venter than dorsum. Septal necks short and slightly recurved. Connecting rings expanded within the camerae, and segments of the siphuncle more or less pyriform in shape, as they are abruptly contracted adorally and are more gradually contracted adapically.

Remarks.—The specimens from the Brentwood limestone of Arkansas and the Morrow of Oklahoma that Mather (1915, pp. 241, 242, pl. 16, figs. 7, 8) described as "*Orthoceras* sp." probably are conspecific with the form under consideration, but we have not seen them.

Occurrence.—All of the above-described specimens came from a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither

Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.). Typical representatives of *Mooreoceras normale* are widely distributed in the Pennsylvanian of North America, and apparently the species ranges throughout most of this series.

Described specimens.—State Univ. Iowa, no. 1987.

Genus COLOCERAS Hyatt, 1893

COLOCERAS spp.

Our collections from the Morrow contain four small fragmentary coiled nautiloids, which seem to be referable to *Coloceras*. At any rate, their conchs are nautiloconic and their external sutures are straight and directly transverse. The umbilici are moderately large and the umbilical shoulders rounded. In at least three of these specimens, the adapical portion of the conch is subelliptical in cross section as it is depressed dorso-ventrally and is more broadly rounded dorsally than ventrally. In all but the first volution of the conch, the whorls are reniform in cross section, as they are depressed dorso-ventrally, slightly impressed dorsally, broadly rounded ventrally, and more narrowly rounded laterally. Test of adapical portions of conch in at least two specimens reticulate, being marked by prominent longitudinal and transverse lirae. Transverse lirae sinuous, forming broadly rounded lateral salients and rather prominent narrowly rounded ventral sinuses. Siphuncle small, central in position, and presumably orthochoanitic in structure.

The preserved part of the largest of the specimens, which is septate throughout, attained a maximum diameter (measured across the umbilicus) of about 20 mm, and an external mold preserved in the matrix which adheres to this specimen shows that originally the conch completed at least one more volution. Since all four of these specimens are small, probably all are immature, and therefore their generic affinities are questionable. Apparently not all of them are conspecific.

Occurrence.—The largest of the specimens came from the Morrow on Greenleaf Creek, 3½ miles southeast of Braggs, Okla. (sec. 2, T. 13 N., R. 20 E.), where it was found in association with *Glaphyrites oblatus* and *Cravenoceras? morrowense*. The other three very small specimens came from a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southeast of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.).

Described specimens.—State Univ. Iowa, nos. 1985, 1986.

Genus BACTRITES Sandberger, 1843

BACTRITES sp.

Plate 43, figure 5

Only one representative of Sandberger's genus *Bactrites* is known from the Morrow. It consists largely of an internal mold of three camerae of the phragmacone, but portions of three more camerae are represented by fragments of the same specimen. The conch is straight, circular in cross section, and very gradually expanded orad. The phragmacone attains a diameter of at least 6 mm. The test is not preserved, but the internal mold is smooth. The sutures are directly transverse to the long axis of the conch and are straight except along the venter, where apparently each forms a small lobe. Camerae are slightly but distinctly longer than wide. Siphuncle small in size, circular in cross section, and ventral and marginal in position.

Remarks.—Since the nature of the surface of the test of this specimen is not ascertainable, it is not possible to make adequate comparisons with the congeneric forms known from the Carboniferous of North America, *B. carbonarius* Smith, *B. quadrilineatus* Girty, *B. smithianus* Girty, and *B. postremus* Miller. In all four of these species the camerae are appreciably shorter than in the specimen under consideration, but with only one specimen to study we are somewhat uncertain as to how much

significance should be attached to this character.

Occurrence.—The above-described specimen came from a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.).

Figured specimen.—State Univ. Iowa, no. 1984.

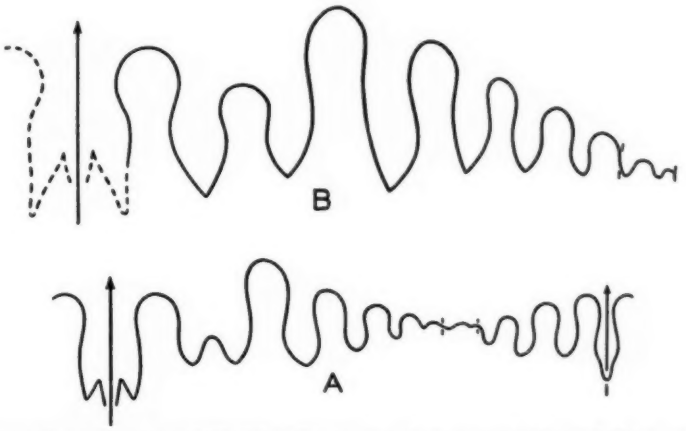

FIG. 1.—*Pronorites arkansasensis* Smith. Diagrammatic representations of (A) an early mature suture, ×5; and (B) a late mature suture, ×2. The first (A) is based on the figured specimen, whereas the last (B) is based on the large fragmentary specimen (mentioned in the text) that has ribs on the test.

Genus PRONORITES Mojsisovics, 1882

PRONORITES ARKANSASENSIS Smith

Plate 43, figures 8, 9

Goniatites cyclolobus WILLIAMS [not Phillips], *1900*, Arkansas Geol. Survey, Ann. Rept. 1892, vol. 5, p. 359.

Pronorites cyclolobus arkansasensis SMITH, *1896*, Am. Philos. Soc., Proc., vol. 35, pp. 267–270, pl. 24, figs. 1–4; *1897*, Leland Stanford Junior Univ. Pub., pp. 57–60, pl. 24, figs. 1–4; *1903*, U. S. Geol. Survey, Mon. 42, pp. 43–46, pl. 12, figs. 12–15; *1914*, Leland Stanford Junior Univ. Pub., Univ. ser., pl. 12, figs. 11, 12.

Pronorites arkansasensis SMITH, *1913*, Zittel-Eastman Textbook of Paleontology, vol. 1, ed. 2, p. 633, text fig. 1183.—MILLER, *1930*, Jour. Paleontology, vol. 4, p. 394.—PLUMMER and SCOTT, *1937*, Texas Univ., Bull. 3701, pp. 57–59, pl. 2, figs. 1–4.

We are referring to this species five specimens, all of which agree well with the published descriptions indicated in the synonymy. These specimens are strikingly similar to the holotype, which is in the U. S. National Museum. Because the lithology of the holotype is precisely similar to that of our specimens, and the locality from which it came is only about 10 miles from Gaither Mountain, where our specimens were collected, it seems almost certain that the holotype, like our specimens, came from the Hale formation. The differences in the diagrammatic representations of the sutures which we have prepared and those which Smith has published are largely matters of interpretation, and are more apparent than real.

Our collections contain a fragmentary specimen, much larger than the holotype, in which the conch attains a height of about 35 mm, though it is septate throughout. This large specimen retains the test, or a replacement of it, and on the ventro-lateral and ventral portions of the test there are small, low, rather inconspicuous transverse ribs, which are about 3.5 mm apart on the venter. These ribs form low broadly rounded salients as they cross the ventral zones of the conch, and they are very much like those of *Pronorites kansasensis* Newell.

Remarks.—Originally Smith regarded this form as a variety of *Pronorites cyclolobus* (Phillips), which is widespread in the Viséan of Europe, occurring in England, Belgium, Germany, etc. Smith subsequently recognized that the American form should probably be regarded as a distinct species, and this is the view of other authors.

Occurrence.—The holotype of this species came from the Hale formation (lower Morrow) on Pilot Mountain, 3.5 miles southwest of Valley Springs, Carroll County, Ark. (NE. $\frac{1}{4}$ sec. 18, T. 17 N., R. 19 W.); and the specimens we are studying came from a limestone lens in the same formation on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.). Also, Plummer and Scott record the occurrence of conspecific specimens in the Smithwick shale (Bend) 3.5 miles east of Rochelle, McCulloch County, Tex.

Figured specimen.—State Univ. Iowa, no. 1983. The four unfigured specimens from the same locality are numbered 1982.

Genus CRAVENOCERAS Bisat, 1928

CRAVENOCERAS? MORROWENSE
Miller and Moore, n. sp.
Plate 43, figures 1–3

Conch ammoniticonic, subglobular, and moderately large; phragmacone attains a maximum diameter (measured across the umbilicus) of as much as 78 mm, though the vast majority of the numerous specimens in our collections are less than 20 mm in diameter. Length of living chamber not known. At maturity whorls are depressed dorso-ventrally, being about two-thirds as high as wide, and more or less helmet-shaped in cross section as they are rather broadly rounded ventrally and laterally and impressed dorsally; depth of impressed zone is equal to about two-fifths height of conch. Diameter of umbilicus increases gradually during late stages of ontogenetic development, and in large individuals it is equal to about one-third that of specimen. Umbilical shoulders subangular; umbilical walls steep but broadly rounded.

Test smooth and marked only by the growth-lines. Each of these forms a shallow broadly rounded ventral sinus and on either side of the conch a similar lateral salient. On the umbilical shoulders the growth-lines become fasciculate. Internal mold (but not exterior of test) is marked by rounded transverse constrictions, which are essentially parallel to the growth-lines. There are about five of these constrictions to the volution.

As shown by text-figure 2, at maturity each suture forms a large moderately narrow prominently bifid ventral lobe and on either side of it a high rounded asymmetrical first lateral saddle, a deep pointed V-shaped first lateral lobe, a lower asymmetrical rounded second lateral saddle, a broad shallow V-shaped lobe that centers on the umbilical wall, a low rounded asymmetrical internal second lateral saddle, a small deep pointed internal first lateral lobe, and a rather high narrow rounded club-shaped internal first lateral saddle, which extends to the deep narrow pointed tongue-shaped dorsal lobe. During late maturity the inflections (both lobes and saddles) become more pronounced, the lobes more acuminate, and the saddles more narrowly rounded (compare text-figs. 2A and 2B).

Remarks.—This species is perhaps more closely similar to *Gastrioceras richardsonianum* Girty of the Caney shale of Oklahoma and the Barnett shale of Texas than to any other form known from America. Bisat referred that species to *Homoceras* Hyatt, whereas Plummer and Scott referred it to *Cravenoceras* Bisat. In the genotype of *Cravenoceras*, *C. malhamense* (Bisat), the conch is more nearly globular and, what is more important, the ventral lobe of the sutures is narrower than in our form. The genotype of *Homoceras* is *H. calyx* (Phillips), the figured type of which is an immature specimen that Bisat thinks is probably conspecific with the type

specimen of *"Goniatites" platylobus* Phillips. If *"G." platylobus* and the specimens generally referred to *Homoceras* by the British paleontologists are to be regarded as typical of the genus *Homoceras*, our form may be referable to it also. At the same time, the specimens we are studying seem to be closely similar to certain forms that Bisat and others refer to *Cravenoceras*. That is, in many respects our species appears to be more or less intermediate between those that are regarded as typical of *Homoceras* and those that are regarded as typical of *Cravenoceras*. In view of the uncertainty in regard to the genotype of *Homoceras*, we are referring our species with question to *Cravenoceras* rather than to *Homoceras*. It differs from *C.? richardsonianum* particularly in that its conch is more broadly rounded ventrally and the ventral lobe of its sutures is somewhat broader.

Occurrence.—Abundant in a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.); also in the Morrow on Greenleaf Creek, 3.5 miles southeast of Braggs Okla. (sec. 2, T. 13 N., R. 20 E.).

Syntypes.—State Univ. Iowa, nos. 1981 (pl. 43, fig. 1), 1980 (pl. 43, figs. 2, 3), 1979 (unfigured specimens from Gaither Mountain), and 1978 (unfigured specimens from Greenleaf Creek).

Genus GASTRIOCERAS Hyatt, 1883

"GASTRIOCERAS" PYGMAEUM Mather

Plate 44, figures 3, 4

Gastrioceras pygmaeum MATHER, *1915*, Denison Univ., Sci. Lab., Bull., vol. 18, pp. 243, 244, pl. 16, figs. 11, 11*a*.—CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, p. 85.
Cravenoceras pygmaeum PLUMMER and SCOTT, *1937*, Texas Univ., Bull. 3701, p. 265.

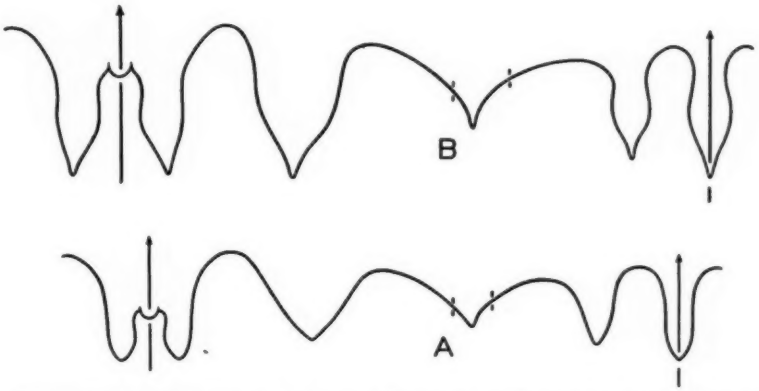

FIG. 2.—*Cravenoceras? morrowense* Miller and Moore, n. sp. Diagrammatic representations of (A) an early mature suture, ×4; and (B) a late mature suture, ×1½. The first (A) is based largely on the specimen represented by figures 2 and 3 on plate 43, whereas the last (B) is based on the specimen represented by figure 1 on the same plate.

Through the courtesy of Prof. Carey Croneis we have been permitted to study the figured syntype of this species and the syntype on which Mather based his published suture drawing. Both of these are almost certainly immature, and since they were not found associated with mature specimens it is not possible to determine their generic affinities. Furthermore, since Mather states that the dozen or so syntypes of this species exhibit considerable variation, it seems quite probable that they are not all conspecific or even congeneric. The figured specimen retains its test and therefore sutures are not visible on it. At least the external sutures of the

other specimen under consideration are of a primitive gastrioceran type, but equal-sized specimens of several genera possess similar sutures.

Occurrence.—Both of the specimens being studied came from the Brentwood limestone member of the Bloyd shale (upper Morrow) in an abandoned quarry 3.5 miles northeast of Fayetteville, Ark., in the S. ½ sec. 2, T. 16 N., R. 30 W. Other syntypes came from the Brentwood in an outcrop near a road 1½ miles northeast of Fayetteville, in the center of sec. 10, T. 16 N., R. 30 W.; and from the Morrow about 8 miles east and 2 miles north of Wagoner, Okla., in sec. 1, T. 17 N., R. 19 E.

Syntypes.—Both the figured syntype and the specimen (syntype) on which Mather's published suture drawing is based are at Walker Museum, Univ. Chicago, no. 16121.

Genus BRANNEROCERAS Plummer and Scott, 1937

BRANNEROCERAS BRANNERI var. BRANNERI (Smith)

Plate 44, figures 5–12

Gastrioceras branneri SMITH, *1896*, Am. Philos. Soc. Proc., vol. 35, pp. 257, 258, pl. 23, figs. 1–6; *1897*, Leland Stanford Junior Univ. Pub., pp. 47, 48, pl. 23, figs. 1–6; *1903*, U. S. Geol. Survey, Mon. 42, pp. 83, 84, pl. 11, figs. 8–13; *1914*, Leland Stanford Junior Univ. Pub., Univ. ser., pl. 1, figs. 12–14.—MATHER, *1915*, Denison Univ., Sci. Lab., Bull., vol. 18, p. 242, pl. 16, figs. 12, 12a.—CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, p. 81.

Goniatites branneri WILLIAMS, *1900*, Arkansas Geol. Survey, Ann. Rept. 1892, vol. 5, p. 359.

Branneroceras branneri PLUMMER and SCOTT, *1937*, Texas Univ., Bull. 3701, pp. 218–221, pl. 11, figs. 1–7.

Conch, which is gradually expanded orad and at full maturity consists of at least 10 volutions, is evolute, subdiscoidal, and moderately large; phragmacone attains a diameter (measured across the umbilicus) of more than 53 mm. Whorls depressed dorso-ventrally (being only three-fourths to three-fifths as high as wide), broadly rounded ventrally and more narrowly so laterally, and slightly impressed dorsally; typically, depth of impressed zone, which varies somewhat, is equal to only about one-fifth height of conch. Umbilical shoulders rounded and not very definite. Diameter of umbilicus varies, and in the specimens that we are referring to this variety it ranges from about three-fifths to two-thirds that of specimen. Length of living chamber not known.

Surface of test marked by prominent transverse growth-lines, each of which forms a V-shaped ventral sinus and on either side of it a rather narrowly rounded ventro-lateral salient. On the lateral zones of the conch the growth-lines become fasciculate and form rather prominent transverse ribs, which extend across the umbilical shoulders to the umbilical seam before becoming obsolete; these ribs are present throughout ontogenetic development. At full maturity the test is reticulate as it bears longitudinal lirae as well as transverse growth-lines. These lirae are not developed on the inner volutions of the conch (see pl. 44, figs. 9, 10), and they are very faint on the umbilical zones of the outer volutions. They are not very prominent on the lateral zones of even large specimens, but on the ventral zones of late mature specimens they are about as well developed as are the transverse growth-lines (see pl. 44, figs. 11, 12).

As shown by text-figure 3B, at maturity each suture forms a deep rather narrow very prominently subdivided ventral lobe and on either side of it a high slightly asymmetrical U-shaped first lateral saddle, a more or less V-shaped acuminate first lateral lobe, a relatively low asymmetrical rounded second lateral saddle, a relatively shallow V-shaped acuminate lobe on the umbilical wall, a rounded asymmetrical internal second lateral saddle, a deep narrow pointed internal first lateral lobe, and a rounded U-shaped internal first lateral saddle, which extends to the deep narrow pointed tongue-shaped dorsal lobe. During late maturity all of the

lobes of the internal sutures become tongue-shaped and acuminate. The median secondary saddle in the ventral lobe is high. The prongs (secondary lobes) of the ventral lobe are deep, narrow, and acuminate, and they are asymmetrically tongue-shaped.

The ratio of the width to the height of the conch is not a very reliable characteristic to use in the differentiation of species or varieties, for it varies during ontogenetic development and is affected by any distortion which the specimen may have undergone during fossilization.

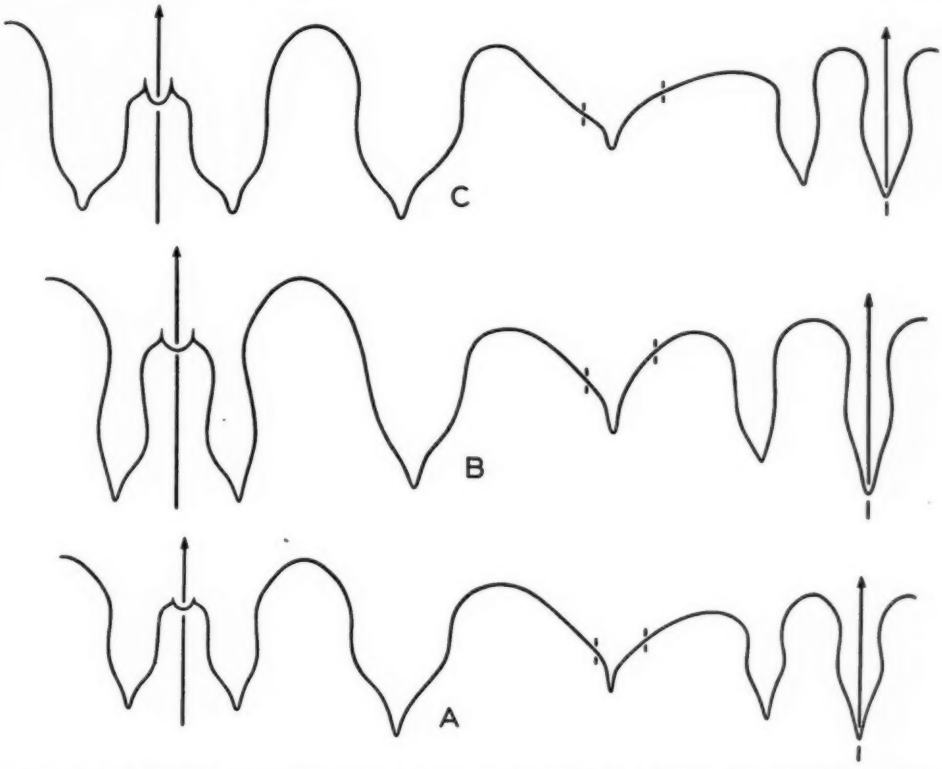

FIG. 3.—Diagrammatic representations of mature sutures of (A) *Glaphyrites oblatus* Miller and Moore, n. sp., ×2½ (based largely on the holotype); (B) *Branneroceras branneri branneri* (Smith), ×3 (based on unfigured hypotypes); and (C) *Phaneroceras kesslerense* (Mather), ×5 (based on the holotype).

Remarks.—Our collections from the Morrow contain some fifty specimens that we believe to be conspecific with Smith's holotype of *Branneroceras branneri*, which we studied in the U. S. National Museum. However, there is considerable variation among these specimens in so far as the amount of depression of the conch and particularly the size of the umbilicus are concerned. The relative size of the umbilicus is not readily altered by distortion and seems to be a fairly reliable character, though in this species it is rather difficult to determine precisely because the umbilical shoulders are not very definite. However, in our collections from a single horizon and locality in the Morrow there is almost complete gradation between forms with umbilici that have diameters equal

to about two-thirds that of the specimen and those that have diameters equal to considerably less than half that of the specimen. Accordingly, we are recognizing two varieties of the species. Since the diameter of the umbilicus of the holotype is equal to almost three-fifths that of the specimen, we are placing forms with large umbilici in the typical variety and are proposing a new varietal name for those with small umbilici. The representative of this species which Mather figured has a large umbilicus. The Texas specimen which Plummer and Scott recently illustrated and referred to this species appears to be poorly preserved and incomplete, but it has a large umbilicus; therefore, if, as Plummer and Scott contend, it belongs to this species, it should be referred to the typical variety.

Occurrence.—The holotype came from the Hale formation (lower Morrow) on Pilot Mountain, 3.5 miles southwest of Valley Springs, Carroll County, Ark. (NE. ¼ sec. 18, T. 17 N., R. 19 W.); and the numerous specimens we are studying came from a limestone lens in the same formation on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.). The specimen illustrated by Mather came from the lower portion of the Morrow formation at Keough Quarry, 2 miles north of Ft. Gibson, Okla.; and Mather states that the same species occurs in a limestone lens near the top of the Hale formation, on the southern slope of East Mountain, Fayetteville, Ark. The Texas specimens illustrated by Plummer and Scott came from the Bend group on the right bank of the Colorado River, about 1 mile southwest of Bend, Tex.; and these authors also refer to this species a specimen which they state "probably is from the Smithwick shale of the Bend group, from Bend, San Saba County," Tex.

Types.—U. S. National Museum, no. 26439 (holotype); Walker Museum, Univ Chicago, no. 16124 (hypotype: pl. 44, figs. 5, 6); Univ. Texas (hypotype figured by Plummer and Scott, no. T-12548, and unfigured specimen, both from Bend of Texas); and State Univ. Iowa (hypotypes nos. 1977 [pl. 44, figs. 9, 10]; 1976 [pl. 44, figs. 11, 12]; and 1975 [unfigured specimens]).

BRANNEROCERAS BRANNERI var. HALENSE Miller and Moore, n. var.
Plate 44, figures 13, 14

We are establishing this variety for representatives of *Brannerоceras branneri* in which the umbilicus is relatively small and its diameter is less than one-half that of the specimen. The diameter of the umbilicus of the holotype of this species (see pl. 44, figs. 7, 8) is neither particularly large nor particularly small, but our measurements show that it is

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EXPLANATION OF PLATE 43

All specimens illustrated on this plate came from the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.).

FIGS. *1–3—Cravenoceras? morrowense* Miller and Moore, n. sp. Ventral view of a large syntype, ×1; and lateral and ventral views of a smaller syntype showing transverse constrictions, ×2. (p. 346)

4—Pseudorthoceras knoxense (McChesney). A small specimen, ×1. (p. 343)

5—Bactrites sp. Ventral view of an internal mold, showing sutures and siphuncle, ×3. (p. 344)

6, 7—Bisatoceras secundum Miller and Moore, n. sp. Two views of a syntype, showing the internal sutures of an adoral volution of the conch, ×3. (p. 353)

8, 9—Pronorites arkansasensis Smith. Lateral and ventral views of a small specimen, ×2. (p. 345)

10, 11—Glaphyrites oblatus Miller and Moore, n. sp. Two views of the holotype, ×1½. (p. 352)

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equal to almost three-fifths that of the specimen. The diameter of the umbilicus of the specimen we are illustrating as typical of the new variety (see pl. 44, figs. 13, 14) is equal to only about two-fifths that of the specimen.

In so far as size and shape of conch, nature of surface markings of test, and form of sutures are concerned, this variety does not differ materially from the typical form.

Occurrence.—Limestone lens in Hale formation on east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.).

Types.—State Univ. Iowa, nos. 1974 (holotype of the new variety: pl. 44, figs. 13, 14) and 1973 (five unfigured paratypes of the new variety).

Genus PHANEROCERAS
Plummer and Scott, 1937

PHANEROCERAS KESSLERENSE (Mather)
Plate 44, figures 1, 2

Gastrioceras kesslerense MATHER, *1915*, Denison Univ., Sci. Lab., Bull., vol. 18, pp. 242, 243, pl. 16, figs. 10–10b.—CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, p. 87, pl. 22, figs. 3–5.

Conch subdiscoidal in shape as whorls are only slightly depressed, are broadly rounded ventrally and laterally, and are impressed dorsally. Holotype, which is septate throughout and therefore represents only phragmacone, attains a maximum diameter (measured across the umbilicus) of about 24 mm and a maximum height and width of conch of about 9.5 mm and 12.5 mm, respectively. Near the adoral end of the penultimate volution of the holotype the conch is about 5.5 mm high and 7.5 mm wide. The impressed zone of the holotype attains a maximum depth of about 4 mm.

Umbilicus moderate in size and its diameter equal to about one-third that of specimen. Umbilical shoulders rounded and maximum width of conch is attained slightly ventrad of them. Umbilical walls fairly steep.

No trace of surface ornamentation is discernible on the holotype. The internal mold of the conch is marked, however, by rounded transverse constrictions of which there appear to be about five to the volution. These constrictions are slightly sinuous and they form shallow ventral and lateral sinuses and ventrolateral salients. They seem to be more prominent on the outer volution of the holotype than on the inner volutions, and apparently they do not extend dorsad of the umbilical shoulders.

As shown by text-figure 3C, each suture forms a broad prominently subdivided ventral lobe and on either side of it a rounded U-shaped first lateral saddle, a large broad slightly asymmetrical tongue-shaped first lateral lobe, a broad very asymmetrical narrowly rounded second lateral saddle, a low broad attenuate lobe which centers on the umbilical wall, a broad rounded asymmetrical internal second lateral saddle, a narrow pointed tongue-shaped internal first lateral lobe, and a slightly broader rounded internal first lateral saddle which extends to the deep pointed tongue-shaped dorsal lobe. The prongs (secondary lobes) of the dorsal lobe are nearly straight-sided but they are acuminate. They are distinctly broader than the secondary saddle that separates them.

Remarks.—The holotype of this species is composed of fine-grained limonitic material. It is fragmentary and incomplete, but it is fairly well preserved.

This species is closely similar to all three of the other forms that have been referred to Plummer and Scott's genus *Phaneroceras: P. compressum* (Hyatt), which is the genotype, and *P. lenticulare* Plummer and Scott of the Bend of Texas, and *P. amotapense* (Thomas) of the Upper Carboniferous of Peru. Because of the differences in size and preservation of the type specimens of these species, it is not possible to make satisfactory comparisons. It seems probable, however, that it would be difficult to differentiate well-preserved equal-sized representatives of them.

Occurrence.—The holotype of this species came from the Kessler limestone member of the Bloyd shale (upper Morrow) near the city water reservoir on the west slope of East Mountain, Fayetteville, Ark. According to Mather, this species occurs also in the Morrow along the road near a branch of Brush Creek, 2.5 miles south and 1 mile east of Choteau, Okla., in the S. ½ sec. 6, T. 19 N., R. 19 E.

Holotype.—Walker Museum, Univ. Chicago, no. 16123.

FIG. 4.—Diagrammatic representation of a mature suture of *Bisatoceras secundum* Miller and Moore, n. sp., ×4 (based on the syntypes).

depressed dorso-ventrally and are helmet-shaped in cross section as they are broadly rounded ventrally and ventrolaterally and impressed dorsally. At adoral end of figured portion of holotype, which is about 40 mm in diameter, conch is about 28.5 mm wide and 16 mm high, and impressed zone is about 8 mm deep. Umbilicus deep, and its diameter is equal to about three-eighths that of specimen; umbilicus of figured portion of holotype attains a maximum diameter of about 15 mm. Umbilical shoulders abruptly rounded and umbilical walls steep.

Test moderately thick and smooth. On the surface of the test (but not the internal mold) there is a small rounded keel on the umbilical shoulders. None of the numerous specimens available for study retains the growth-lines or traces of them. On the internal mold,

Genus GLAPHYRITES Ružencev, 1936

GLAPHYRITES OBLATUS
Miller and Moore, n. sp.
Plate 43, figures 10, 11

Conch subglobular and moderately large, and phragmacone attains a maximum diameter (measured across the umbilicus) of at least 50 mm. Whorls are

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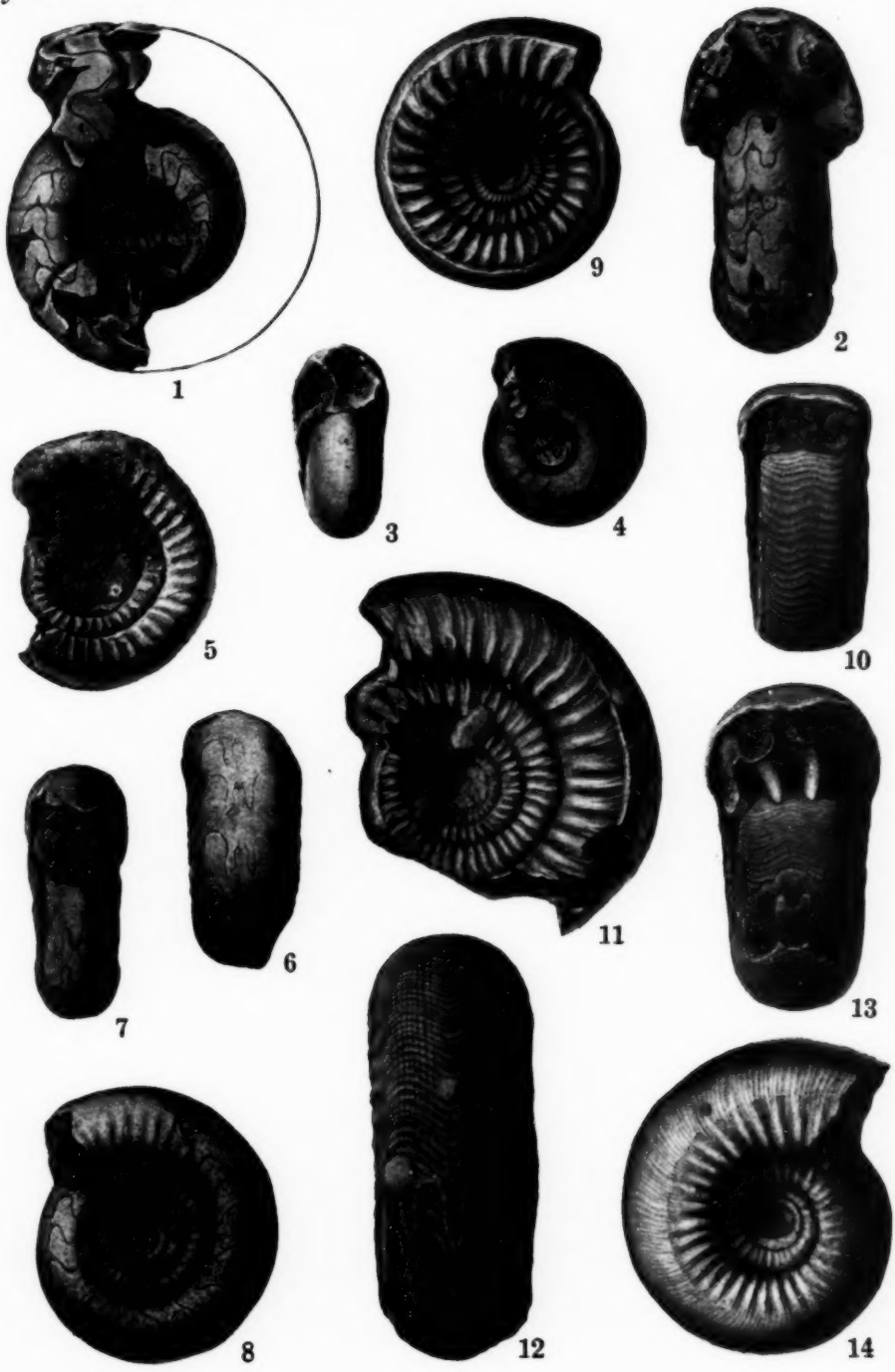
EXPLANATION OF PLATE 44

FIGS. *1, 2*—*Phaneroceras kesslerense* (Mather). Two views of the holotype, ×2; from the Kessler limestone member of the Bloyd shale (upper Morrow) at Fayetteville, Ark. (p. 351)

3, 4—*"Gastrioceras" pygmaeum* Mather. Ventral and lateral views of the figured syntype, ×5; from the Brentwood limestone member of the Bloyd shale (upper Morrow), 3.5 miles northeast of Fayetteville, Ark. (p. 347)

5–12—*Branneroceras branneri* var. *branneri* (Smith) Miller and Moore. Two views (figs. *5*, *6*) of the specimen figured by Mather, ×1; from the Morrow formation, 2 miles northeast of Fort Gibson, Okla. Ventral and lateral views (figs. *7*, *8*) of the holotype, ×1; from the Hale formation (lower Morrow) on Pilot Mountain, Carroll County, Ark. Two views (figs. *9*, *10*) of a small, immature specimen, ×2½; from the Hale formation on Gaither Mountain, about 7 miles southwest of Harrison, Ark. Lateral and ventral views (figs. *11*, *12*) of a large, mature specimen, showing the internal sutures of an adoral volution of the conch, ×1; from the same horizon and locality as the last. (p. 348)

13, 14—*Branneroceras branneri* var. *halense* Miller and Moore, n. var. Two views of a rather small well-preserved specimen (the holotype of the new variety), ×2; from the same horizon and locality as the last. (p. 350)



Miller and Moore, Morrow Cephalopods

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however, there are low rounded transverse constrictions, which are slightly sinuous and form a low broad rounded ventral salient and similar ventro-lateral sinuses. There are about four of these constrictions to the volution, and they are not very prominent. Presumably they are parallel (or essentially so) to the growth-lines.

As shown in text-figure 3A, at maturity each suture forms a low broad prominently bifid ventral lobe and on either side of it a rather broad rounded first lateral saddle, a deep acuminate tongue-shaped first lateral lobe, a broad rounded asymmetrical second lateral saddle, a broad V-shaped acuminate lobe on the umbilical wall, a low broad rounded asymmetrical internal second lateral saddle, a small narrow pointed tongue-shaped internal first lateral lobe, and a rounded club-shaped internal first lateral saddle which extends to the rather deep narrow pointed tongue-shaped dorsal lobe. The prongs (secondary lobes) of the ventral lobe are almost straight-sided but they are acuminate. They are about equal in width to the secondary saddle which separates them.

Remarks.—With the exception of *Cravenoceras? morrowense*, this form is the most abundant ammonoid species in our collections from the Morrow. It appears to be a typical representative of the genur *Glaphyrites*. Its rather narrow umbilicus distinguishes it from the upper Pennsylvanian genotype, *G. modestus* (Böse), and such lower Pennsylvanian forms as *G. subcavus* (Miller and Gurley) and *G. welleri* (Smith).

Mature representatives of this species bear a superficial resemblance to those of the form that we are describing above as *Cravenoceras? morrowense*, and it may be that that species should be referred to *Glaphyrites*. However, its conch is relatively narrower than is that of the species under consideration and, what is more important, its transverse constrictions (and growth-lines) form ventral sinuses rather than salients. Immature representatives of *Glaphyrites oblatus* are very much broader than are those of *Cravenoceras? morrowense*.

Occurrence.—Abundant in a limestone lens in the Hale formation (lower Morrow) on the east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.); and occurs also in the Morrow on Greenleaf Creek, 3.5 miles southeast of Braggs, Okla. (sec. 2, T. 13 N., R. 20 E.).

Types.—State Univ. Iowa, nos. 1972 (holotype: pl. 43, figs. 10, 11), 1971 (unfigured paratypes from Gaither Mountain), and 1970 (unfigured paratypes from Greenleaf Creek).

Genus BISATOCERAS
Miller and Owen, 1937

BISATORCERAS SECUNDUM
Miller and Moore, n. sp.
Plate 43, figures 6, 7

Conch subdiscoidal or sublenticular at maturity, and phragmacone attains a maximum diameter (measured across the umbilicus) of at least 30 mm. Conch wider than high during early growth stages, but at full maturity it becomes slightly higher than wide. Umbilicus small and closed. Umbilical shoulders low, rounded, and inconspicuous. Length of living chamber not known.

At least during early maturity each growth-line forms a very shallow rounded ventral sinus and similar ventro-lateral and dorso-lateral salients and lateral sinuses. Also, internal mold of early volutions of conch is marked by transverse constrictions, which are approximately parallel to the growth-lines, but are even less strongly sinuous and are therefore nearly straight. As full maturity is approached these transverse constrictions disappear. Test also marked by fine longitudinal lirae, but we are uncertain as to whether these are on the inner or outer surface of the test, or on both surfaces.

At maturity each suture forms a low, very broad prominently subdivided ventral lobe and on either side of it a

rounded U-shaped first lateral saddle, a pointed V-shaped first lateral lobe, a low, broad asymmetrical broadly rounded second lateral saddle, a shallow depressed-V-shaped lobe that centers just outside the umbilical seam, a low broad asymmetrical broadly rounded internal second lateral saddle, a small narrow V-shaped internal first lateral lobe, and a small U-shaped first lateral saddle, which extends to the narrow pointed tongue-shaped dorsal lobe. The median secondary saddle in the ventral lobe is high. The prongs (secondary lobes) of the ventral lobe are short and broad, their sides are nearly parallel, and they are bluntly and asymmetrically pointed.

Remarks.—This species is very similar to *Bisatoceras primum* Miller and Owen of the Coffeyville formation (lower Missouri subseries) of Oklahoma, the only other congeneric form known. However, the longitudinal lirae on its test readily differentiate it from that species.

Occurrence.—Limestone lens in Hale formation (lower Morrow) on east side of Gaither Mountain, about 7 miles southwest of Harrison, Ark. (sec. 27, T. 18 N., R. 21 W.).

Types.—State Univ. Iowa, nos. 1969 (figured syntype) and 1968 (seven unfigured syntypes).

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THE GRIES RANCH FAUNA (OLIGOCENE) OF WESTERN WASHINGTON

WILLIAM LLOYD EFFINGER

The Gries Ranch fauna was first described by R. E. Dickerson (1917). The principal collections of Gries Ranch mollusks come from a rather inconspicuous outcrop on the southeast bank of the Cowlitz River, in Lewis County, Wash., about 4 miles east of Vader (sec. 25, T. 11 N., R. 2 W.). At the time the first collections were made, the ranch upon which the locality occurs was occupied by a Mr. Gries, and the fauna has generally been referred to since as the Gries Ranch fauna.[1] Although this fauna has generally been correlated with the *Molopophorus lincolnensis* zone of Weaver (1916a), considered to be lower Oligocene, the large percentage of new species and the fact that the fauna shows important affinities with the Eocene, have made its age uncertain. The problem of correlation has been complicated by the question of facies, as the fossils at Gries Ranch are associated with sediments which suggest different environmental conditions from those of the typical *Molopophorus lincolnensis* zone or those which are typical of most fossil localities in the Cowlitz formation. The difficulties are increased by the fact that the strata exposed at Gries Ranch represent a small outcrop isolated by a surrounding cover of alluvium and vegetation from the more complete sections of Tertiary rocks exposed to the west.

[1] This is an unfortunate name, as the occupants of the ranch have changed, and the present-day Gries Ranch is farther to the north. However, as the name is in common usage, it would be difficult to replace it with one less familiar. The original spelling used by Dickerson was "Greeco." It has subsequently been spelled "Greece," "Graeco," and "Gries." Persons well acquainted with the family say that the correct spelling is "Gries."

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HISTORICAL REVIEW

In 1916 Weaver (1916a) divided the Oligocene deposits of Washington, nearly 15,000 feet in thickness, into three faunal zones, the *Molopophorus lincolnensis* zone (lowest), *Turritella porterensis* zone, and *Acila gettysburgensis* zone. He designated the sedimentary deposits bearing these faunas the Lincoln, Porter, and Blakeley formations, respectively. These deposits overlie the upper Eocene Cowlitz formation and are in turn overlain by the lower Miocene Wahkiakum formation.

Later in the same year Weaver (1916b) discussed the Eocene of the Lower Cowlitz Valley, Washington, and gave a detailed description of the Eocene and lower Oligocene section as exposed on

Stillwater and Olequah creeks, Lewis and Cowlitz counties. The possible contact between Eocene and Oligocene is placed (1916b, pl. 1) about 1.25 miles south of the town of Winlock. The fauna from the Gries Ranch locality, located about 4.5 miles to the southeast of the

The Gries Ranch fauna was described by R. E. Dickerson (1917), based upon a collection made by F. M. Anderson and Bruce Martin, which was placed in the California Academy of Sciences. Dickerson recognized a total of 53 molluscan forms, 48 specifically identifiable,

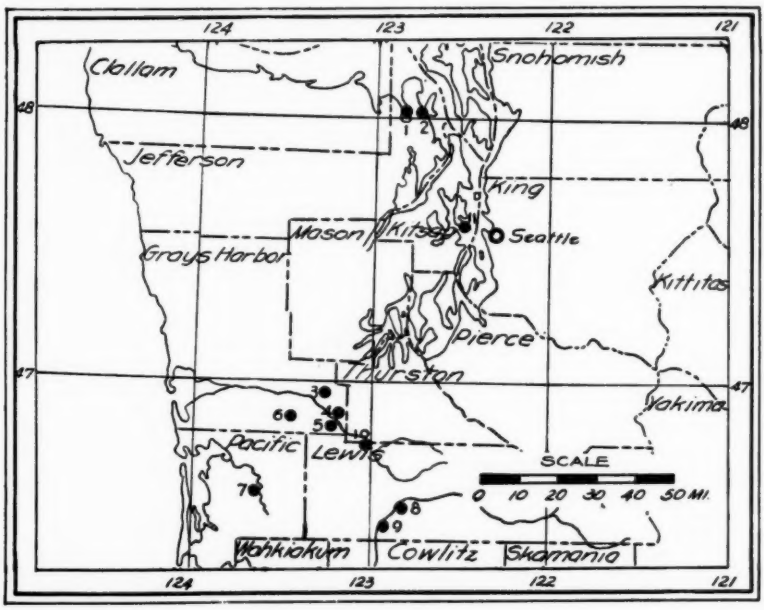


FIG. 1.—Sketch map of western Washington showing location of important fossil localities. *1*, Woodman Wharf, Loc. A-10; *2*, Classen's Wharf, Loc. A-890; *3*, Porter Creek, Loc. A-364; Oakville Quarry, Loc. A-368; *5*, Balch Station; *6*, Locality at Girrard School, Loc. A-21; *7*, Willapa River locality near Nallapee; *8*, Gries Ranch locality, Loc. 3607; *9*, Locality type Cowlitz formation; *10*, Locality type Lincoln zone; *11*, Locality type Blakeley zone.

Olequah Creek section (loc. 239 on Weaver's map), is considered to be of lower Oligocene age, and the Eocene-Oligocene contact, when projected from Olequah Creek across the intervening area in which the bed rock is obscured, to the Cowlitz River, is placed about 0.25 mile below the Gries Ranch locality. The fauna from Gries Ranch is stated to be equivalent to that of localities 292 and 229 (Weaver's map) in the Olequah Creek section; these are all thought to represent the *Molopophorus lincolnensis* zone.

including 36 new species (75 per cent), 8 believed to be characteristic of the *Molopophorus lincolnensis* zone, and 4 long-ranged forms which continued to live in Miocene times. Dickerson did not recognize any Eocene species, but he believed the general cast of the fauna to be Eocene. The general assemblage he interpreted as indicating a subtropical climate and the coarse character of the sediments and abundance of *Hipponix*, *Patella*, *Crepidula* and *Acmaea* marked the fauna as strictly littoral in character. Dickerson correlated this fauna with the

Molopophorus lincolnensis zone, but stated that

> its distinctiveness is due in part to its strictly littoral character and in part to having lived in a portion of Oligocene time older than the typical *Molopophorus lincolnensis* zone.

The following year Van Winkle (1918) suggested that the lowermost Oligocene deposits of the Chehalis Valley, Grays Harbor County, Wash., are slightly lower than the typical *Molopophorus lincolnensis* zone, and designated them as the "*Barbatia merriami* zone." She considered the lower portion of the *Turritella porterensis* zone to represent the equivalent of a part of the *Molopophorus lincolnensis* zone; the upper portion, the lower *Acila gettysburgensis* zone. Van Winkle described one new pelecypod and nine new gastropods from the Gries Ranch locality, and of the 58 species known from Gries Ranch, she regarded five as also occurring in the *Molopophorus lincolnensis* zone. Van Winkle suggested that

> a more detailed study of the fauna in this locality will result in the finding of a larger number of species, many of which will probably be common to the Lincoln Creek beds. The reason for the small number of species in common between the Gries Ranch and the *Molopophorus lincolnensis* fauna can probably be accounted for in the fact that the former lived in comparatively shallow water, while the *Molopophorus lincolnensis* fauna is typically a moderate to deep water facies.

The Gries Ranch deposits are correlated with the upper part of the *Barbatia merriami* zone.

The Gries Ranch fauna has been referred to subsequently in many papers dealing with the Oligocene of the Pacific Coast, especially those of Schenck (1928), Clark (1918), and Tegland (1933). In these papers the Gries Ranch fauna generally has been considered to represent a distinct zone older than the *Molopophorus lincolnensis* zone.

SUMMARY OF STRATIGRAPHY

In the Gries Ranch region, the fossils occur in two lithologic members, a gradational contact between indicating that both belong to the same formation. The upper bed is a grayish-brown conglomerate, 2 to 3 feet thick, composed mainly of small pebbles of basalt containing numerous shells, mostly *Ostrea*. The lower bed is composed principally of blue-gray, medium-grained sandstone about 4 feet thick, containing numerous excellently preserved shells of pelecypods and gastropods. These deposits dip to the north at an angle of 2° to 4°, but may be traced along the river bank for only approximately 30 feet. To the north they disappear beneath the valley alluvium; to the south they abut sharply against a small mass of basaltic breccia, in fault contact with the sandstones. The basaltic breccia is in fault contact with unfossiliferous, well-stratified sandstones, which dip 4° to the south. During periods of extremely low water, almost continuous exposures may be seen in the southeastern bank of the river for a distance of approximately one-half a mile south of the fossil locality. These deposits form a shallow syncline, the axis of which trends northwest-southeast, crossing the Cowlitz River about 1,000 feet downstream from the Gries Ranch locality. The dips are generally low and the beds are duplicated on the two limbs of the structure so that the total stratigraphic thickness represented is slightly more than 100 feet. These deposits consist of sandstones and pebbly conglomerate with basaltic breccias and shales. The sandstones are usually tuffaceous and often contain great quantities of volcanic ash.

A pacing and compass traverse made along the bank of the river (see Fig. 2) reveals the following stratigraphic succession and approximate thickness:

SECTION AT THE GRIES RANCH LOCALITY

	Feet
Recent	
River alluvium, unconsolidated mud, sand and gravel	
Unconformity	
Oligocene (Gries Ranch beds)	
Dark, greenish-gray, thinly stratified crumbly shale	8
Fine- to medium-grained, pebbly conglomerate, cross-bedded and contain-	

ing thin beds of tuff	15
Fine conglomerate and coarse sandstone	10
Local unconformity	
Fine-grained and coarse, poorly sorted, gray sandstone	15
Fine-grained gray tuffaceous sandstone containing numerous fossil mollusks (loc. A-1424)[2]	3
Coarse gray sandstone containing much tuff and pumice	8

The fossiliferous sandstone mentioned outcrops 2,000 feet downstream from the Gries Ranch locality. It contains numerous specimens; however, they lack the fine preservation found at Gries Ranch. From a small collection the following species were identified: *Lucina* (*Here*) *dalli* (Dickerson), *Macoma*

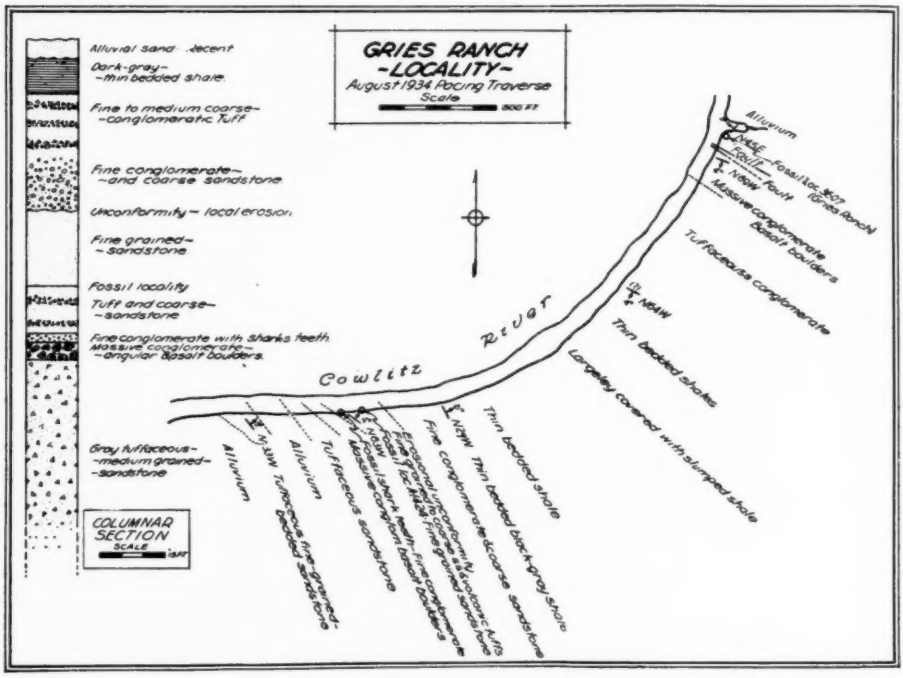


FIG. 2.—Traverse of Gries Ranch beds, and columnar section at type locality. The fossil locality indicated in the section is A-1424.

Fine brownish pebbly conglomerate containing numerous fossil shark's teeth	2
Massive basaltic breccia containing angular pieces of basalt up to 3 or more feet in diameter	10
Gray medium-grained well-stratified tuffaceous sandstones	35
Total thickness	106

[2] All specimen and locality numbers refer to collections in the Museum of Paleontology, University of California, unless otherwise indicated. Abbreviations used are: U.W., University of Washington; C.A.S., California Academy of Sciences.

sp., *Nuculana merriami* (Dickerson), *Pitar clarki* Dickerson, *Septifer* sp., *Spisula packardi* Dickerson, *Tellina townsendensis* Clark, *Thracia* sp., *Elimia*, n. sp. (same as at Gries Ranch), "*Molopophorus*" *bramkampi*, n. sp., *Molopophorus stephensoni* Dickerson.

This locality is on the south limb of the syncline and probably corresponds to the fossiliferous sandstone at Gries Ranch. The normal relationships of the beds here have not been disturbed by

local faulting, and their position has been determined as midway in the exposed section. The basaltic breccia, faulted against the fossil sandstones at Gries Ranch, appears to be the same as that occurring only a few feet below the fossiliferous sandstone on the south limb of the syncline. If this is true, the faults separating the Gries Ranch locality from the rest of the section have a very small displacement and are in all probability within the formation.

These deposits are isolated from the more extensive exposures of bed-rock, which occur to the west along the Cowlitz River and Olequah Creek (Weaver, 1916b), by an intervening cover of alluvium and vegetation. Weaver pointed out that the deposits exposed in the vicinity of Gries Ranch are in all probability represented in the Olequah Creek section a short distance south of Winlock, and the relationships to the Eocene have been, stated to be as follows:

The actual contact of the upper limit of the Tejon and the overlying Oligocene has not been definitely determined. Four hundred feet south of the last Oligocene outcrop in the banks of Olequah Creek are Eocene shales containing a marine Tejon fauna. It is impossible to say whether the two formations are conformable or not. The strata have approximately the same strike, but the dip of the Oligocene is only 2° to the northeast, while that of the Tejon is 27° in the same direction. It is possible that the two formations are conformable but that in the interval of 400 feet between, the dip flattens out.

TENTATIVE CORRELATION TABLE

	NW WASHINGTON	CEN WASHINGTON	SW WASHINGTON	N & CEN OREGON	CEN CALIFORNIA	SO CALIFORNIA	MISSISSIPPI-EMBAYMENT	EURODE
MIOCENE	Clallam Form	Astoria Form	Astoria Form	Astoria Form	Contra Costa / Vaqueros	Temblor / Vaqueros	Alum Bluff Group	Helvetian Aquitanian
OLIGOCENE Upper	Twin Rivers	Blakeley form (C E Weaver)	Blakeley ?	Nye shales	San Ramon Form (B L Clark) / Kirker Form (B L Clark)	Upper Pleito Form (Wagner & Schilling)	Byram Marl	Chattian
OLIGOCENE Middle	Lincoln Zone (Upper Lincoln Form of C E Weaver)	Porter Form (C E Weaver) / Type Lincoln Zone (Upper Lincoln Form)	Lincoln Zone	Pittsburg Bluff Beds / Eugene Form	San Lorenzo Form (R Arnold)	Lower Pleito Form / San Emigdio Form (Wagner & Schilling)	Glendon Form	Rupelian
OLIGOCENE Lower	Woodmont Wharf Port Hadlock & Cok Bay Beds (Lower Lincoln form of C E Weaver)	Barbatia mcmurami Zone of Van Winkle (Lower Lincoln Form) / Break	Type Gries Ranch	Willapa River Shales	Keasey shales / ?Butano SS ?	? / Upper Turritella variata Zone	Mariano Ls & Red Bluff Clay	Latdorfian (Sannoisian)
	Break		Break	Break	Break	Lr Temblor Zone	Jackson	Ludian Bartonian
EOCENE	Middle Eocene Port Crescent	Cowlitz Form	Cowlitz Form	Cooledo	Markley Form (B L Clark)	Tejon	Claiborne	Auversian Lutetian

FIG. 3

ANALYSIS OF THE GRIES RANCH FAUNA

A total of 75 fossil species has been identified from the Gries Ranch beds. The species of mollusks greatly outnumber all other groups, 27 species of pelecypods and 48 species of gastropods having been recognized; the remainder are corals, bryozoans, worm tubes, echinoid spines and plates, barnacles and shark teeth. Numerous Foraminifera

are represented. The species occurring in the Gries Ranch beds are indicated in the check list.

ECOLOGY

Dickerson (1917) and Van Winkle (1918) have previously pointed out the subtropical character of the Gries Ranch fauna. *Arca*, *Acar*, *Cardita*, *Chama*, *Cucullaria*, *Lima*, *Pedalion*, *Acteon*, *Conus*, *Hipponix*, *Marginella*, *Terebellum*, and *Volvulella* indicate subtropical waters. Most of the other genera have a wider temperature range but are common in warm waters. Two species, however, represent groups which today are confined to cold waters. These are *Trichotropis alienensis*, n. sp. and *Turritellopsis? weaveri* (Van Winkle), and their occurrence amid subtropical associates is puzzling. *Trichotropis* is known only from two specimens. *Turritellopsis*, however, is common and the delicate shell and fine sculpturing preclude the possibility of its being washed up from deeper waters. Both species are very small.

The abundance of sessile, near-shore forms such as *Hipponix*, *Acmaea*, *Crepidula* and numerous plates of barnacles, as well as the coarse, poorly sorted character of the sediments, indicate a near-shore or littoral facies. This is especially true of the upper conglomeratic zone. The lower fossiliferous sandstone, containing an abundant fauna predominantly of gastropods, seems to represent a slightly deeper water facies, but probably not over 200 to 300 feet in depth and still located fairly near shore.

CORRELATION

Relationship to the "Barbatia merriami zone."—The faunas showing the closest relationship to that found at Gries Ranch occur in the "*Barbatia merriami* zone" of Van Winkle (1918), in the Chehalis Valley region of central western Washington; and from deposits generally considered to be lowermost Oligocene in the vicinity of Port Townsend on the northern Olympic Peninsula, Washington.

The type locality of the "*Barbatia merriami* zone"[3] is located in the hills to the north of Chehalis Valley, in the vicinity of Porter and Oakville. The beds are typically shown on Porter Creek 3.5 miles above its junction with the Chehalis River (loc. A-364), and at the northwest end of a basalt quarry 1 mile west of Oakville, on the Northern Pacific Railroad tracks (loc. A-368). Here it consists of 20 to 75 feet of moderately coarse to fine pebbly, fossiliferous conglomerates. These beds have a generally low dip to the southwest and immediately overlie basalts of Eocene age, separated by a well-marked erosional unconformity. The conglomerates are almost entirely derived from this basalt. About 75 feet stratigraphically above the contact the conglomerates grade into 1,200 feet of medium-grained micaceous sandstones. The upper portion of these sandstones, exposed along the Chehalis River in the vicinity of Porter, constitutes the type section of the Porter beds of Weaver, now generally considered to be a part of the *Molopophorus lincolnensis* zone. Close to 50 species have been identified from these conglomerates of the "*Barbatia merriami* zone," many apparently new. Twenty-one species are identical or closely related to Gries Ranch species; these are indicated on the check list ("*Barbatia merriami* zone").

This zone is also represented in the basal part of beds mapped (Etherington, 1931, map) as Lincoln formation in various other parts of Grays Harbor County. Small faunas from localities near the

[3] "*Barbatia merriami*" Van Winkle, considered the most characteristic fossil of this zone, was later shown to belong to *Arca* rather than *Barbatia*. I consider this species to be conspecific with *Arca washingtoniana* Dickerson, an earlier designation, and a common Gries Ranch species.

Garrard School House (loc. A-21), and on the Clemmon's logging railroad contain characteristic species of this zone.

Relationship to other lowermost Oligocene faunas of Washington.—Certain faunas from the northern Olympic Peninsula in the vicinity of Port Townsend, Wash., show an interesting relationship to that from Gries Ranch. These occur in a rather thin zone in the sedimentary deposits, which immediately overlie Eocene igneous rocks. One important locality is situated on the east shore of Discovery Bay, one-fourth mile north of Woodman Station (now called Ramona Beach). The fossils occur in a conglomerate sandstone 100 to 150 feet stratigraphically above the contact with the igneous rocks, the actual contact being obscured by an area of glacial drift and soil. The fossiliferous beds are overlain by an extensive thickness of gray medium-grained sandstones, the upper part of which contains fossils typical of the *Molopophorus lincolnensis* zone. Twenty-eight molluscan species from this locality have been identified as forms occurring at Gries Ranch; these are indicated on the check list (Woodman Wharf).

Less extensive collections have been obtained from Classen's Wharf, near Port Hadlock, and from the basal sedimentary deposits on Oak Harbor. The latter locality is believed to represent about the same horizon as that exposed at Woodman Station. Although the fauna from Classen's Wharf contains a few species in common with that at Gries Ranch, a large number are typically Lincoln forms. This might be expected from its somewhat higher stratigraphic position, and the fauna appears to be transitional between the Gries Ranch and the *Molopophorus lincolnensis* zones.

In Pacific and Wahkiakum counties there are extensive deposits of dark shales, close to 1,000 feet thick, overlying the Cowlitz formation and overlain by the Lincoln zone. The shales are generally unfossiliferous, but in a few localities, as along the Willapa River north of Nallipee, good collections have been obtained. The generic assemblage is markedly different from that occurring at Gries Ranch, so that direct faunal correlations are not possible. However, from their similar stratigraphic position there is a strong suggestion that these dark shales may represent a deeper-water facies of the Gries Ranch zone. As has been pointed out by Schenck (1927, p. 457; 1928, p. 36), paleontologic evidence indicates that these shales are equivalent to the Keasey shales of Columbia County, Ore.

Relationship to the Molopophorus lincolnensis zone.—Although the Gries Ranch fauna has often been correlated with a part of the Lincoln zone, its distinctiveness from the fauna of the type *Molopophorus lincolnensis* zone has seldom been overlooked. Dickerson (1917, p. 161) listed seven species occurring at Gries Ranch which are characteristic of the *Molopophorus lincolnensis* zone; all but one, *Epitonium condoni* Dall, were misidentified. In addition, he considered that *Neverita nomlandi* Dickerson and *Galeodea dalli* Dickerson occur at Pittsburg Bluff, Ore.; *Barbatia gabbi* Dickerson, *Pitar clarki* Dickerson, and *Acteon parvum* Dickerson near Clatskanie, Ore.; *Spisula packardi* Dickerson in the San Emigdio formation; and that *Tellina abrupta* Conrad, *Tellina oregonensis* Conrad, and *Pecten branneri* Arnold range throughout the Oligocene. The last three are misidentified; and I have not been able to substantiate the occurrence of *Galeodea dalli* in the Pittsburg Bluff beds. The exact age of the deposits near Clatskanie is somewhat uncertain.

Only nine species (three questionable, one a long-ranged species) which occur in the Gries Ranch beds have been observed in deposits belonging to the *Molopophorus lincolnensis* zone. These are.

COMPARISON OF SPECIES FROM THE GRIES RANCH FAUNA AND THE LINCOLN HORIZON

Gries Ranch Species	Closely Related Species in the Lincoln Horizon
Loxocardium etheringtoni, n. sp.	*Cardium lincolnensis* Weaver
Lucina (*Here*) *dalli* (Dickerson)	*Lucina* (*Here*) *richthofeni* (Gabb)
Pitar (*Lamelliconcha*) *clarki* Dickerson	*Pitar dalli* Weaver
Tellina (*Tellina*) *townsendensis* Clark	*Tellina oregonensis* Dall
Acteon parvum Dickerson	*Acteon chehalisensis* Weaver
Acrilla dickersoni Durham	*Epitonium* (*Acrilla*) *lincolnensis* Weaver
Exilia weaveri Dickerson	*Exilia lincolnensis* Weaver
Scaphander washingtonensis sub-sp. *goodspeedi*, n. sub-sp.	*Scaphander washingtonensis* Weaver
Spirotropis (*Spirotropis*) *winlockensis*, n. sp.	*Spirotropis dickersoni* (Weaver)
"*Whitneyella*" *gabbi* (Dickerson)	"*Whitneyella*" *lincolnensis* Van Winkle

Tellina (*Moerella*) *lincolnensis* Weaver; *Calyptraea diegoana* (Conrad) (ranges from lower Eocene through Oligocene); *Galeodea* cf. *fax* Tegland (known from Gries Ranch by incomplete material only); *Natica* (*Natica*) cf. *weaveri* Tegland; *Polinices lincolnensis* (Weaver); *Spisula packardi* Dickerson and *Pitar* (*Lamelliconcha*) *clarki* Dickerson (may occur in San Emigdio formation); *Solen townsendensis* Clark; and *Epitonium* (*Boreoscala*) *condoni* Dall.

There are a few other forms which are very closely related to species from the Lincoln beds.

Although the marked differences between the Gries Ranch fauna and that of the type *Molopophorus lincolnensis* zone have often been attributed to a difference in facies, it seems unlikely that this is the principal cause of their differentiation. A comparison of the faunal list from these two localities reveals much the same generic assem-

COMPARISON OF SPECIES FROM THE GRIES RANCH FAUNA AND THE COWLITZ OR TEJON FORMATIONS

Gries Ranch Species	Closely Related Species in the Cowlitz or Tejon Formations
Corbula cowlitzensis Dickerson	*Corbula dickersoni* Weaver and Palmer
Crassatella perrini (Dickerson)	*Crassatella stillwaterensis* (Weaver and Palmer)
Gari martini (Dickerson)	*Gari columbiana* (Weaver and Palmer)
Glycymeris andersoni Dickerson	*Glycymeris sagittata* var. *dickersoni* Weaver and Palmer
Mya arnoldi (Dickerson)	"*Corbula*" *stillwaterensis* Weaver and Palmer
Nuculana merriami (Dickerson)	*Nuculana cowlitzensis* (Weaver and Palmer)
Pitar (*Lamelliconcha*) *clarki* Dickerson	*Pitar eocenica* Weaver and Palmer
Cerithiopsis merriami (Dickerson)	*Cerithiopsis vaderensis* (Dickerson)
Homalopoma? sp.	*Homalopoma wattsi* (Dickerson)
Marginella (*Cryptospira*?) *instabilata* Hanna	*Marginella multifilosa* Anderson and Hanna
Siphonalia packi (Dickerson)	*Siphonalia bicarinata* Dickerson
"*Whitneyella*" *gabbi* (Dickerson)	"*Whitneyella*" *washingtoniana* (Weaver)

SUMMARY OF FAUNAL RELATIONSHIPS

Total number of identified molluscan species in Gries Ranch fauna	75
Number of species common to Cowlitz	7
Number of species common to "*Barbatia merriami* zone"	21
Number of species common to fauna at Woodman Wharf	28
Number of species common to last two localities	34
Number of species common to *Molopophorus lincolnensis* zone (including questionable forms)	9
Number of species known only to Gries Ranch	36

blage at both, which seems to preclude the possibility of any marked difference in environmental conditions.

Relationship to the Cowlitz formation.—Seven species of mollusks have been identified as common to the Cowlitz (upper Eocene) and the Gries Ranch faunas; these are indicated in the check list.

In addition, the Gries Ranch species listed on page 362 are closely related to forms occurring in the Cowlitz or Tejon formations.

SUMMARY

The Gries Ranch fauna occurs at the type locality in southwestern Washington, at localities near Woodman Wharf, Port Hadlock, and near the little town of Mots-mots on Oak Bay, in northern Washington; at localities representing the "*Barbatia merriami* zone" of Van Winkle in Grays Harbor County, central western Washington; and possibly at localities on Grays River in southwestern Washington and at Clatskanie in northern Oregon. The large number of Gries Ranch species occurring in the "*Barbatia merriami* zone" and the lowermost Oligocene deposits of the Port Townsend region strongly suggests that these are equivalents of the Gries Ranch zone.

It seems likely that the Gries Ranch may be correlated with the Willapa River shales of southwestern Washington and the Keasey shales of Oregon, but their faunas are apparently of a deeper-water facies. Correlatives in California may be vaguely indicated by the occurrence of *Pitar clarki* and *Spisula packardi* in the San Emigdio formation; and by the occurrence of *Strepsidura lincolnensis* var. *lorenzana* Wagner and Schilling (1923, p. 243) in the San Emigdio formation and in the deposits at Woodman Station (loc. A-10). The occurrence of *Terebellum* cf. *andersoni* (Dickerson) and *Siphonalia* cf. *packi* (Dickerson) in the fauna from the upper *Turritella variata* Conrad zone (Woodring, 1930, p. 160) of the western Santa Ynez Mountains, Santa Barbara County, Calif., is slightly suggestive, but stratigraphic and faunal studies carried on by me in this region are as yet incomplete.

The Gries Ranch fauna and deposits represent a distinct faunal zone younger than the Cowlitz (Eocene) and older than the type Lincoln faunal zones, but are about as closely related to the one as to the other. The tuffaceous character of the deposits at Gries Ranch is similar to the type of lithology often met with in the Cowlitz formation, but so far as I am aware is not known from deposits of the Lincoln zone; and unfossiliferous strata of this character elsewhere have been included with the Eocene. No sharp break is apparent between the Cowlitz formation and the possible correlatives of the Gries Ranch zone on Olequah Creek. In Grays Harbor County to the north, the "*Barbatia merriami*" beds overlie the Eocene basalts with marked unconformity, and the same unconformable relationships exist between the possible correlatives of the Gries Ranch beds and the Eocene in the Port Townsend region.

In the Gries Ranch fauna, however, there is a noticeable absence of certain important Eocene genera such as the large *Venericardia*, *Rimella*, *Ficopsis*, *Pseudoperissolax* and *Surculites*. Furthermore, the major stratigraphic break in the Lower Tertiary sequence in western Washington is below rather than above the Gries Ranch zone. Although at present there is no apparent means of making a direct correlation between what has generally been considered Oligocene on the West Coast and that of the Gulf region or the type section in Germany, it seems most logical to consider the Gries Ranch zone as lowermost Oligocene in age.

TABLE I.—CHECK LIST OF GRIES RANCH FAUNA

SPECIES	Gries Ranch Locality 3607	Gries Ranch Locality A-1424	Cowlitz	"*Barbatia merriami* zone"	Woodman Wharf	*Molopophorus lincolnensis* zone	Eugene	San Emigdio	Blakeley
LAMELLIBRANCHIATA									
Arca washingtoniana Dickerson	x	—	—	x	x	—	—	—	—
Barbatia (Acar) reinharti Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Cardita (Carditamera) weaveri Dickerson	x	—	—	x	x	—	—	—	—
Chama grunskyi Hanna	x	—	—	—	—	—	—	—	—
Corbula cowlitzensis Dickerson	x	—	—	x	—	—	—	—	—
Crassatella perrini (Dickerson)	x	—	—	—	—	—	—	—	—
Cucullaria (Porterius) gabbi (Dickerson)	x	—	—	x	—	—	—	—	—
Gari martini (Dickerson)	x	—	—	—	—	—	—	—	—
Glycymeris andersoni Dickerson	x	—	—	—	—	—	—	—	—
Glycymeris winlockensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Lima bella Dickerson	x	—	—	x	x	—	—	—	—
Loxocardium etheringtoni Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Lucina (Here) dalli (Dickerson)	x	—	x	x	x	—	—	—	—
Macoma sp.	—	x	—	—	—	—	—	—	—
Macrocallista cf. *williamsoni* Weaver and Palmer	x	—	x	—	—	—	—	—	—
"*Mya*" *arnoldi* (Dickerson)	x	—	—	—	—	—	—	—	—
Nuculana merriami (Dickerson)	x	—	—	—	—	—	—	—	—
Ostrea griesensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Pecten (Chlamys) grunskyi Hertlein	x	—	—	—	x	—	—	—	—
Pedalion clarki Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Pitar (Lamelliconcha) clarki Dickerson	x	—	—	x	x	x	—	?	—
Saxicava sp.	x	—	—	—	—	—	—	—	—
Semele reagani Dickerson	x	—	—	x	—	—	—	—	—
Septifer sp.	—	x	—	—	—	—	—	—	—
Solen townsendensis Clark	x	x	—	—	x	x	—	?	—
Spisula packardi Dickerson	x	—	—	x	x	x	—	x	—
Taras griesensis Effinger, n. sp.	x	—	x	x	x	—	—	—	—
Taras sp.	C.A.S. Loc. 181	—	—	—	—	—	—	—	—
Tellina (Moerella) lincolnensis Weaver	x	x	—	x	x	x	—	—	—
Tellina (Tellina) townsendensis Clark	x	—	—	—	x	—	—	—	—
"*Tellina*" *gibsonensis* Van Winkle	x	—	—	—	—	—	—	—	—
GASTROPODA									
Acmaea ocitatia Hanna	x	—	—	x	x	—	—	—	—
Acmaea simplex Dickerson	x	—	—	x	x	—	—	—	—
Acrilla (Ferminoscala) dickersoni Durham	x	—	—	—	x	—	—	—	—
Acteon parvum Dickerson	x	—	—	—	x	—	—	—	—
Alvania lettana (Van Winkle)	x	—	—	—	—	—	—	—	—
Bittium howardi (Dickerson)	x	—	—	—	—	—	—	—	—
Calyptraea diegoana (Conrad)	x	—	x	x	x	x	—	—	?
"*Cancellaria*" *landesi* Van Winkle	x	—	—	—	—	—	—	—	—
Cerithiopsis merriami (Dickerson)	x	—	—	—	—	—	—	—	—
Cerithiopsis washingtoniana (Dickerson)	x	—	x	—	—	—	—	—	—
Cirsochilus washingtonianus Effinger, n. sp.	x	—	—	—	—	—	—	—	—

TABLE I—*Continued*

SPECIES	Gries Ranch Locality 3607	Gries Ranch Locality A-1424	Cowlitz	"*Barbatia merriami* zone"	Woodman Wharf	*Molopophorus lincolnensis* zone	Eugene	San Emigdio	Blakeley
Clavatula arnoldi (Van Winkle)	x	—	—	—	—	—	—	—	—
Cominella eocenica (Weaver)	x	—	x	—	—	—	—	—	—
Conus ruckmani Dickerson	x	—	—	—	x	—	—	—	—
Crepidula pileum (Gabb)	x	—	x	—	—	—	—	—	—
Cylichnina turneri Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Cypraeogemmula warnerae Effinger, n. sp.	x	—	—	—	x	—	—	—	—
Elimia sp., probably new	x	—	—	—	—	—	—	—	—
Epitonium (*Boreoscala*) *condoni* Dall	x	—	—	—	x	x	x	x	—
Exilia weaveri Dickerson	x	—	—	—	—	—	—	—	—
"*Fusinus*" *gesteri* Dickerson	x	—	—	—	—	—	—	—	—
Galeodea dalli Dickerson	x	—	—	—	x	—	—	—	—
Galeodea cf. *fax* Tegland	x	—	—	—	x	x	—	—	—
Hipponix arnoldi Dickerson	x	—	—	x	—	—	—	—	—
Homalopoma? sp.	x	—	—	—	x	—	—	—	—
Liotia weaveri Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Littorina oligocenica Dickerson	x	—	—	—	—	—	—	—	—
Marginella (*Cryptospira?*) *instabilata* Hanna	x	—	—	x	x	—	—	—	—
Melanella (*Melanella*) *clarki* (Dickerson)	x	—	—	—	—	—	—	—	—
Melanella sp.	x	—	—	—	—	—	—	—	—
Molopophorus bramkampi Effinger, n. sp.	x	—	—	—	x	—	—	—	—
Molopophorus stephensoni Dickerson	x	—	—	x	x	—	—	—	—
Natica (*Natica*) cf. *weaveri* Tegland	x	—	—	—	—	x	—	—	—
Neverita nomlandi Dickerson	x	—	—	—	x	—	—	—	—
Odostomia griesensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Odostomia (*Evalea*) *hiltoni* (Van Winkle)	x	—	—	—	—	—	—	—	—
Odostomia (*Odostomia*) *winlocki-and* Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Phalium cf. *egberti* Schenck	x	—	—	—	—	—	—	—	—
Polinices lincolnensis (Weaver)	x	—	—	x	x	x	—	—	—
Scaphander washingtonensis subsp. *goodspeedi* Effinger, n. subsp.	x	—	—	x	x	—	—	—	—
Siphonalia packi (Dickerson)	x	—	—	—	—	—	—	—	—
Spirotropis winlockensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Terebellum andersoni (Dickerson)	x	—	—	—	—	—	—	—	—
Trichotropis alienensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Trophon calamitus (Hanna)	x	—	—	—	—	—	—	—	—
Turbella cowlitzensis Effinger, n. sp.	x	—	—	—	—	—	—	—	—
Turritellopsis ? weaveri (Van Winkle)	x	—	—	—	—	—	—	—	—
Urosalpinx, n. sp.	x	—	—	x	—	—	—	—	—
Volvulella tabor Effinger, n. sp.	x	—	—	—	—	—	—	—	—
"*Whitneyella*" *gabbi* (Dickerson)	x	—	—	x	—	—	—	—	—
ANTHOZOA									
Balanophyllia cf. *variabilis* Nomland	x	—	—	—	—	—	—	—	—

SYSTEMATIC DESCRIPTION

Citations of fossils given in the synonymies accompanying the systematic descriptions refer to reports listed at the end of this paper.

Phylum MOLLUSCA
Class LAMELLIBRANCHIATA
Order PRIONODESMACEA
Family NUCULANIDAE

Genus NUCULANA Link, 1807

Genotype, *Arca pernula* Müller.

NUCULANA MERRIAMI (Dickerson)
Plate 46, figure 5

Leda merriami DICKERSON, *1917*, p. 166, pl. 27, figs. 1*a*, 1*b*.
Leda washingtonensis Weaver, DICKERSON, *1917*, p. 160.

Immature specimens of this species closely resemble *N. washingtonensis* (Weaver) (1916a, p. 34, pl. 3, figs. 27–29), from the Lincoln beds, in outline and general appearance, but the former possess a diagonal groove on the escutcheon which is lacking on the Lincoln forms. The material on which Dickerson based his identification of *N. washingtonensis* from Gries Ranch has not been seen, but the species has not been found in the abundant material at hand from that locality.

Family PARALLELODONTIDAE

Genus CUCULLARIA Conrad, 1869

Genotype, *Arca heterodonta* Deshayes. Lutetian-Bartonian (Eocene) of Paris Basin.

Subgenus PORTERIUS Clark, 1925

Genotype, *Barbatia gabbi* DICKERSON (=*B. andersoni* Van Winkle).

CUCULLARIA (PORTERIUS) GABBI
(Dickerson)
Plate 46, figure 6

Barbatia gabbi DICKERSON, *1917*, p. 167, pl. 27, fig. 4; VAN WINKLE, *1918*, p. 75.
Barbatia andersoni VAN WINKLE, *1918*, pp. 81, 82, pl. 6, fig. 2 ("*Barbatia merriami* zone," Porter Creek, Wash.).
Parallelodon (*Porterius*) *andersoni* (Van Winkle), CLARK, *1925*, p. 80, pl. 9, fig. 3; pl. 10, figs. 1, 6.

Although the holotype of "*Barbatia*" *gabbi* is incomplete, several excellently preserved topotypes have been obtained which are indistinguishable except in their smaller size from "*Barbatia*" *andersoni*. One large specimen from Gries Ranch, length over 40 mm, has the same general outline and ornamentation as the smaller specimens and may represent an adult of this species.

The generic relations of *Cucullaria* have been discussed by Stewart (1930, pp. 66, 67). The genotype of *Cucullaria* (Deshayes, 1860, p. 906, pl. 67, figs. 22–25) has much the same shape and hinge characters as *C. gabbi*. The Gries Ranch form has the short transverse teeth of the hinge situated slightly more toward the anterior end and are fewer in number; the anterior "laterals" of the right valve are shorter and somewhat heavier; the ribbing is dichotomous instead of intercalary; and the beaded ornamentation is lacking. It seems desirable to utilize the subgenus *Porterius* for this group, but it must be shifted to the genus *Cucullaria*.

Family GLYCYMERIDAE

Genus GLYCYMERIS da Costa, 1778

Genotype, *Glycymeris orbicularis* da Costa.

GLYCYMERIS ANDERSONI Dickerson

Glycymeris andersoni DICKERSON, *1917*, pp. 166, 167, pl. 27, figs. 3*a*–3*c*; VAN WINKLE, *1918*, p. 75.

This species closely resembles *Glycymeris sagittata* var. *dickersoni* Weaver and Palmer (1922, p. 10, pl. 8, fig. 5), from the Cowlitz formation near Vader, Wash., but may be distinguished by a persistently wider ligamental area, rounded instead of quadrate outline, and less tumid shape.

GLYCYMERIS WINLOCKENSIS
Effinger, n. sp.
Plate 45, figures 2, 5

Shell small, subcircular, equilateral; valves of low convexity; beaks small, central; anterior and posterior dorsal margins nearly straight, sloping from the

beaks at equal angles; hinge normal, bearing 18 prominent teeth equally divided on both sides of the beaks; ligamental area small, obscure; ornamentation consisting of about 50 slightly rounded, radiating ribs which are crossed by numerous wavy incremental lines; ventral margin internally denticulate, the ridges extending only a short distance from the margin. Dimensions: holotype 14,790, height 16.6 mm, length 16.7 mm, thickness of one valve 4.4 mm.

Family ARCIDAE

Genus ARCA Linné, 1758

Genotype, *Arca noae* Linné.

ARCA WASHINGTONIANA Dickerson

Plate 46, figure 8

Arca washingtoniana DICKERSON, *1917*, p. 166, pl. 27, figs. 2*a*, 2*b*; VAN WINKLE, *1918*, p. 75.
Barbatia merriami VAN WINKLE, *1918*, p. 81, pl. 6, fig. 1 ("*Barbatia merriami* zone," Porter Creek, Wash.).
Arca merriami (Van Winkle), CLARK, *1925*, p. 80, pl. 13, figs. 5–8.

The Gries Ranch locality has thus far yielded only small specimens, few exceeding 7 mm in length, while the type of "*Barbatia merriami*" attains a length of 40 mm. Except for this difference in size there seems to be little basis for the separation of these forms. It seems probable that the smaller forms are immature specimens. Van Winkle regarded "*Barbatia merriami*" as characteristic of the lowermost Oligocene zone, which she designated the "*Barbatia merriami* zone," and its presence in the Gries Ranch fauna is significant.

Stewart (1930, pp. 85, 86) states that *Arca merriami* seems to be the closest relative of *Arca* s. s. ever to reach the northwest coast of America.

Genus BARBATIA Gray, 1842
Subgenus ACAR Gray, 1847

Genotype, *Arca gradata* Broderip and Sowerby. Tropical and subtropical seas.

BARBATIA (ACAR) REINHARTI Effinger, n. sp.

Plate 45, figures 3, 4; Plate 46, figures 1, 2

Shell small, heavy, trapezoidal in outline, beaks fairly prominent, situated one-fifth the length from anterior end; posterior dorsal area concave, bounded ventrally by a well-developed umbonal ridge; anterior umbonal ridge less distinct; medial surface of shell bearing a broad, shallow sulcus; dorsal margin straight, joining the sharply curved anterior end at right angles; posterior end almost straight, forming an angle of 125° with the dorsal edge and joining the ventral margin at an acute angle; ventral margin broadly sinuous; sculpture reticulate, consisting of about 50 fine, radial ribs crossed by numerous concentric growth lines, which give the entire outer surface of the shell a beaded appearance; interior margin denticulate; hinge straight, bearing in the region directly beneath the beaks a strong, short tooth parallel to the axis of the hinge, on either side of which are transversely-mounted curved teeth; teeth on anterior and posterior ends of hinge become progressively larger and lie diagonally across the hinge. Dimensions: holotype 33,504, height 4.3 mm, length 8 mm, thickness of one valve 2.2 mm; paratype 14,793, height 4.1 mm, length 8.9 mm. Named in honor of P. W. Reinhart, who, in his work on the West Coast arcas, first pointed out the distinctness of this form to me.

Family PEDALIONIDAE

Genus PEDALION Huddesford, 1770

Genotype, *Ostrea ephippium* Linné.

PEDALION CLARKI Effinger, n. sp.

Plate 45, figures 9, 10

Shell large, moderately thick, trigonal in outline; beaks prominent, thin, sharply pointed, slightly prosogyrous; anterior margin almost straight, slightly concave; dorsal margin straight, meeting the anterior margin at the beaks at an angle of about 65°; valves moderately convex, sloping gradually along dorsal, posterior and ventral margins but sloping steeply to meet the opposite valve along the anterior margin; prominent byssal notch lacking; dorsal edge thickened to

form an elongate, narrow hinge, the inner face of which bears about 15 narrow transversely mounted U-shaped ligamental grooves, separated by flat areas about twice their width. Dimensions: holotype 33,513, height (slightly incomplete) 160 mm, length 100 mm, thickness of both valves 45 mm; paratype 33,514, height (incomplete) 84.8 mm. Named in honor of Bruce L. Clark, Department of Paleontology, University of California.

Family OSTREIDAE

Genus OSTREA Linné, 1758

Genotype, *Ostrea edula* Linné.

OSTREA GRIESENSIS Effinger, n. sp.

Plate 45, figures 1, 8

Ostrea lincolnensis Weaver, DICKERSON, *1917*, p. 160, pl. 28, fig. 1; VAN WINKLE, *1918*, p. 75 (part).

Valves large, moderately heavy, ovate to rounded in outline, of moderate convexity; beaks out-turned, opisthogyrous; ligamental area large, rough, and in the left valve projecting internally to form an overhanging rostrum; ligamental groove distinct but shallow, moderately wide; anterior margin uniformly convex from the beaks to the ventral margin; posterior margin concave above, convex below; muscle scar distinct, subquadrate to subluniform, located slightly posteroventrally of center of valve; internal surface smooth, undulating; external surface rugose; left valve more convex and attached over a wide area of the shell. Dimensions: holotype 33,510, height 92 mm, length 60 mm, thickness 15 mm; paratype 33,511, height 126 mm, length 104 mm, thickness 23 mm.

This species has been confused with *O. lincolnensis* Weaver (1916a, p. 36, pl. 1, figs. 5, 6), from the Lincoln beds. The Gries Ranch species may be distinguished by its internally projecting ligamental plate, out-turned nature of the beaks, greater convexity of the upper posterior margin, and lack of regular concentric sculpture.

Family PECTENIDAE

Genus PECTEN Müller, 1776

Genotype, *"Ostrea" maxima* Linné.

Subgenus CHLAMYS Bolten, 1798

Genotype, *Pecten islandicus* (Linné).

PECTEN (CHLAMYS) GRUNSKYI Hertlein

Pecten (Chlamys) grunskyi HERTLEIN, *1929*, pp. 296, 297.

Pecten branneri Arnold, DICKERSON, *1917*, pp. 160, 161, pl. 28, fig. 2; VAN WINKLE, *1918*, p. 75.

This species has been confused with *Pecten branneri* Arnold; the status of the latter has been discussed by Loel and Corey (1932, pp. 196, 197), who believe it synonymous with *P. sespeensis* Arnold. *P. grunskyi* rather closely resembles *P. cowlitzensis* Weaver (1912, pp. 30, 31, pl. 5, fig. 46), from the Cowlitz formation near Vader, Wash.; however, comparative material was not available. The figure would suggest that *P. cowlitzensis* is more rounded in outline and possesses fewer ribs.

Several poorly preserved specimens of *Pecten* are represented in the Hannibal collection from the lower Oligocene coarse sandstones of the northern Olympic Peninsula. Although the material is largely fragmentary or in the form of casts, the shape and ribbing closely resemble those of *P. grunskyi*.

Family LIMIDAE

Genus LIMA (Bruguière) Cuvier, 1798

Genotype, *Ostrea lima* Linné. Recent, Indo-Pacific.

LIMA BELLA Dickerson

Lima bella DICKERSON, *1917*, p. 172, pl. 29, fig. 11; VAN WINKLE, *1918*, p. 75.

Lima (Radula) oakvillensis CLARK, *1925*, p. 84, pl. 15, figs. 1 and 3 ("*Barbatia merriami* zone," Oakville quarry, Washington).

Dickerson's description and figure are based upon an immature individual. Several large specimens have been obtained from Gries Ranch, the youthful stages of which correspond accurately with the type of *L. bella*, while the mature form agrees with *L. oakvillensis*. It is to be noted that anterior and posterior ends

have been confused in both Dickerson's and Clark's descriptions of this species.

Order TELEODESMACEA
Family CRASSATELLIDAE

Genus CRASSATELLA Lamarck, 1799

Genotype, *Crassatella gibba* Lamarck.

CRASSATELLA PERRINI (Dickerson)

Astarte perrini DICKERSON, *1917*, p. 168, pl. 27, figs. 8*a*, 8*b;* VAN WINKLE, *1918*, p. 75.
?Crassatellites stillwaterensis WEAVER and PALMER, *1922*, p. 18, pl. 9, figs. 1, 2 (Cowlitz formation, McClarety Ranch near Vader, Wash.).

There are two specimens of *Crassatella stillwaterensis* (Weaver and Palmer) in the Museum collections from McClarety Ranch which compare closely with the larger forms of *C. perrini*, except in the lack of a marked ventral ridge restricting the chondrophore from the visceral cavity. The hinge, however, is somewhat weathered so that the determination will have to await better comparative material.

Family CARDITIDAE

Genus CARDITA Bruguière, 1792
Subgenus CARDITAMERA Conrad, 1838

Genotype, *Cardita arata* (Conrad).

CARDITA (CARDITAMERA) WEAVERI Dickerson

Plate 46, figure 11

Cardita (*Carditamera*) *weaveri* DICKERSON, *1917*, p. 167, pl. 27, figs. 5*a*, 5*b;* VAN WINKLE, *1918*, p. 75.
Paphia landesi VAN WINKLE, *1918*, p. 83, pl. 6, fig. 3.

This species is known only from the Gries Ranch zone.

Family CHAMIDAE

Genus CHAMA Linné, 1758

Genotype, *Chama lazarus* Linné.

CHAMA GRUNSKYI Hanna

Plate 46, figures 9, 10

Chama grunskyi HANNA, *1924*, p. 162.
Chama pacifica DICKERSON (not Broderip), *1917*, p. 172, pl. 29, fig. 10; VAN WINKLE, *1918*, p. 75.

The designation originally used for this species was an exact homonym of a recent species from Lord Hood's Island, Pacific Ocean, named by Broderip (1834, p. 149). The Gries Ranch species was later renamed by Hanna.

Family UNGULINIDAE

Genus TARAS Risso, 1826

Genotype, *Taras antiquatus* Risso.

TARAS GRIESENSIS Effinger, n. sp.

Plate 45, figures 11, 12

Shell of moderate size, thin, orbicular, tumid, equilateral, approaching a hemisphere; beaks inconspicuous, slightly prosogyrous; anterior dorsal margin slightly concave; posterior dorsal margin straight, sloping at an angle of 32° and abruptly merging into the almost perpendicular posterior margin; ventral margin arcuate; hinge small, dentition consisting of two cardinals in the left valve, anterior subumbonal and deeply bifid; posterior cardinal fused dorsally with the lower margin of ligamental groove; anterior cardinal margin depressed; sculpture consists only of fine incremental lines; right valve unknown. Dimensions: holotype 33,520, height 15.5 mm, length 17 mm, thickness 5.8 mm.

This species resembles the recent *T. orbella* (Gould) in general appearance. It may be distinguished, however, by the depressed anterior dorsal margin; the anterior cardinal tooth is mounted almost transverse to the long axis of the hinge while on the recent species it extends diagonally backwards; the ligamental groove is narrower and not nearly so deeply impressed.

An unfigured specimen of *Taras*, in the Museum collections from Port Crescent, Wash. (Loc. 7171), may represent this species. It has the depressed anterior margin similar to *T. griesensis;* however, the hinge has been destroyed.

TARAS? sp.

Diplodonta sp., DICKERSON, *1917*, pl. 29, fig. 9.

This specimen, C.A.S. 444, is the only one, so far as I know, which has been obtained. It lacks anterior and posterior

cardinal margins as well as beak and hinge. The internal cast shows the beaks to be strongly prosogyrous and there is a distinct anterior flexure extending from the anterior ventral margin to the beaks. The surface is ornamented by 10 equally spaced concentric ridges.

Family LUCINIDAE

Genus LUCINA Bruguière, 1797

Genotype, *Venus pensylvanica* Linné.

Subgenus HERE Gabb, 1866

Genotype, *Lucina excavata* Carpenter (=*Lucina* (*Here*) *richthofeni* Gabb).

LUCINA (HERE) DALLI (Dickerson)

Diplodonta dalli DICKERSON, *1917*, p. 171, pl. 29, fig. 8; VAN WINKLE, *1918*, p. 75.

This species occurs in the uppermost Cowlitz formation, upper Eocene, and in the Gries Ranch zone.

Family CARDIIDAE

Genus LOXOCARDIUM Cossmann, 1886

Genotype, *Cardium formosum* Deshayes.

LOXOCARDIUM ETHERINGTONI Effinger, n. sp.
Plate 45, figures 6, 7

Cardium lincolnensis Weaver, DICKERSON, *1917*, pl. 29, figs. 6*a*, 6*b*; VAN WINKLE, *1918*, p. 75 (in part).

Shell medium sized, thin, subovate in outline, inequilateral in youth but becoming more equilateral in maturity; length slightly exceeding height; moderately convex; beaks centrally located, small, slightly prosogyrous; anterior dorsal margin slightly convex, posterior dorsal margin almost straight, merging into steeply sloping truncate posterior end; ventral margin arcuate, with an inconspicuous posterior umbonal ridge; hinge with two cardinals in each valve; left posterior cardinal obsolete; left anterior cardinal large, located a little anterior to the beaks and set diagonally across the hinge; right posterior cardinal slightly larger than right anterior cardinal; between these is a deep triangular socket receiving left anterior cardinal; left valve with anterior and posterior laterals (the posterior may be obsolete in adult) received into corresponding sockets in right valve; ornamentation consisting of 46 to 47 small rounded ribs alternating with intercostal areas of about equal width; extreme anterior and posterior ribs sometimes bear short spines; on mature uneroded specimens central portion of shell is almost smooth; margins serrate, the internal fluting extending only a short distance inward from the margins. Dimensions: holotype 33,524, height 14.5 mm, length 16.3 mm, thickness 6.6 mm; paratype 33,525, height 14.6 mm, length 16 mm, thickness 4.8 mm. Named in honor of T. J. Etherington of the Standard Oil Company of California.

This species differs from *Cardium lincolnensis* Weaver (1916a, p. 40, pl. 3, figs. 36, 37) in its greater length, its less truncate posterior margin, its greater number of ribs (29 on *C. lincolnensis*), and in the character of the internal flutings, which do not extend so far toward the beaks. *L. etheringtoni* seems to be closely related to *L. olequahensis* (Weaver), from the Cowlitz formation, Olequah Creek; however, the latter has smaller beaks and the anterior and posterior cardinal margins meet at a smaller angle than in *L. etheringtoni*.

EXPLANATION OF PLATE 45

FIGS. 1, *8*—*Ostrea griesensis* Effinger, n. sp. (×0.6). *1*, Holotype, 33,510; *8*, paratype, 33,511. (p. 368)

2, *5*—*Glycymeris winlockensis* Effinger, n. sp. (×2.4). Holotype, 14,790 (p. 366)

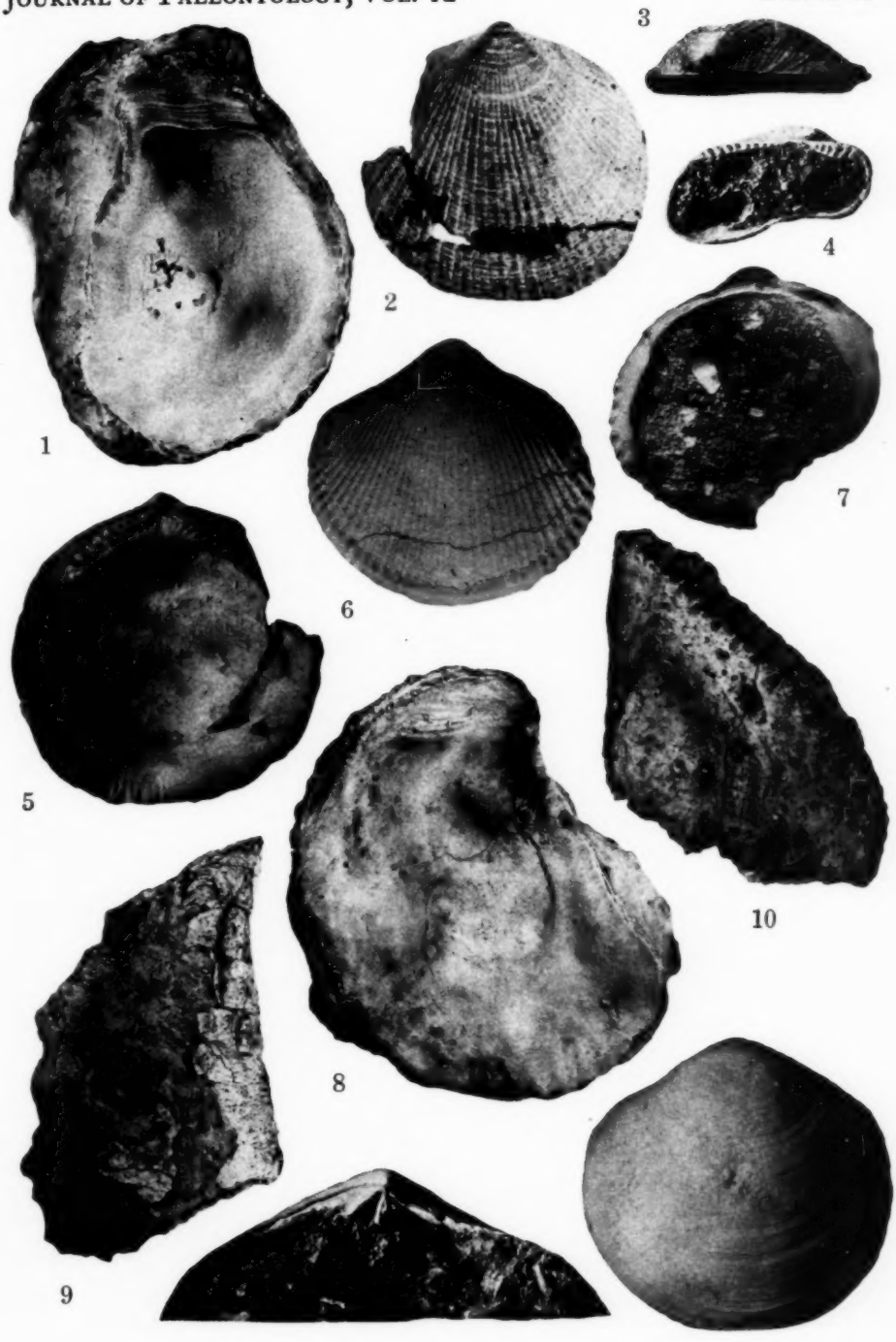
3, *4*—*Barbatia* (*Acar*) *reinharti* Effinger, n. sp. (×3.6). Paratype, 14,793. (p. 367)

6, *7*—*Loxocardium etheringtoni* Effinger, n. sp. (×2.4). *6*, Holotype, 33,524; *7*, paratype, 33,525. (p. 370)

9, *10*—*Pedalion clarki* Effinger, n. sp. *9*, Holotype, 33,513 (×.0.4); *10*, paratype, 33,514 (×0.7). (p. 367)

11, *12*—*Taras griesensis* Effinger, n. sp. Holotype 33,520. *11*, Hinge-line, (×3.6); *12*, (×2.4). (p. 369)

(All specimens from Loc. 3607, unless otherwise indicated)



Effinger, Tertiary Pelecypods

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Family VENERIDAE

Genus PITAR Romer, 1857

Genotype, *Venus tumens* Gmelin.

Subgenus LAMELLICONCHA Dall, 1902

Genotype, *Cytherea concinna* Sowerby.

PITAR (LAMELLICONCHA) CLARKI Dickerson

Pitaria clarki DICKERSON, *1917*, p. 169, pl. 28, figs. 4*a*–4*c*.
Pitaria (*Lamelliconcha*) *clarki* Dickerson, TEGLAND, *1929*, p. 279, pl. 22, figs. 1–4.

The general shape and ornamentation of *Pitar clarki* appear to be intermediate between *P. eocenica* Weaver and Palmer (1922, pp. 20, 21, pl. 10, figs. 14, 16), occurring in the Cowlitz formation, and *P. dalli* Weaver (1916a, p. 41, pl. 1, figs. 1–4), from the Lincoln beds. The shape is somewhat ovate and is more elongate than in the Cowlitz species, but lacks the more extreme length and sharply rounded anterior margin of the Lincoln species. The ribbing is marked by strong, fairly equally spaced concentric ribs, suggestive of those found on *P. eocenica*, but the fine concentric lamellae resemble those of *P. dalli*. It seems highly probable that *P. eocenica*, *P. clarki*, and *P dalli* represent stages in the evolution of a single stock from upper Eocene into middle Oligocene time.

Genus MACROCALLISTA Meek, 1876

Genotype, *Venus gigantea* Gmelin.

MACROCALLISTA cf. WILLIAMSONI Weaver and Palmer

Macrocallista williamsoni WEAVER and PALMER, *1922*, pp. 21, 22, pl. 10, figs. 1, 11 (Cowlitz formation, Coal Creek and McClarety Ranch, Wash.).

Five incompletely preserved specimens of a *Macrocallista* were obtained from Gries Ranch, all of the right valve. The outline, presence of marked concentric ribs, and character of the hinge are similar to *M. williamsoni*. Although somewhat resembling *M. pittsburgensis* (Dall) (1900, pl. 36, fig. 22; pl. 43, fig. 15; 1903, p. 1253) of the Lincoln beds, the Gries Ranch specimens lack the sharply attenuated posterior end characteristic of that species.

Family TELLINIDAE

Genus TELLINA (Linné) Lamarck, 1799

Genotype, *Tellina radiata* Linné. Recent, West Indies.

TELLINA (TELLINA) TOWNSENDENSIS Clark

Plate 46, figure 14

Tellina townsendensis CLARK, *1925*, p. 94, pl. 12, figs. 11, 12 (type from Fossil Creek, Wahkiakum Co., Wash.; paratype from Classen's Wharf locality, Townsend Bay, Wash.).
Tellina oregonensis Conrad, DICKERSON, *1917*, p. 160, pl. 29, fig. 4.

The holotype and paratype are eroded and lack any traces of sculpturing; however, specimens from the same locality as the paratype show the fine incised concentric sculpture identical with that of the form from Gries Ranch.

T. townsendensis is similar to some of the more attenuate varieties of *T. longa* Gabb (Gabb, 1864, p. 155, pl. 22, fig. 131; Weaver, 1916a, p. 24), from the Cowlitz formation and the upper Eocene deposits of western Oregon. The common form found in the upper Eocene is slightly less attenuate posteriorly and somewhat higher, but some of the variants closely approach *T. townsendensis*. *T. eugenia* Dall (1909, p. 124, pl. 19, fig. 3), from the Oligocene of Smith's Quarry, Eugene, Ore., is closely related, but differs in having a shorter pallial sinus.

Subgenus MOERELLA Fischer, 1887

Genotype, *Tellina donacina* Linné.

TELLINA (MOERELLA) LINCOLNENSIS Weaver

Tellina lincolnensis WEAVER, *1916a*, p. 42, pl. 3, fig. 30 (from type Lincoln).
Tellina obruta Conrad, DICKERSON, *1917*, pl. 29, figs. 3*a*, 3*b*.

The forms occurring at Gries Ranch have been confused with *T. obrupta* Conrad (Etherington, 1931, pp. 82, 83, pl. 9, figs. 6, 7, 9, 10), a common form in the Astoria Miocene beds of Oregon and Washington. *T. lincolnensis* differs very markedly from the Miocene form in

having a greater length, a more concave posterior dorsal margin, a more rounded posterior margin, lack of any definite posterior umbonal ridge, and by the absence of a posterior flexure in the valves.

"TELLINA" GIBSONENSIS Van Winkle

Tellina gibsonensis VAN WINKLE, *1918*, pp. 83, 84, pl. 6, fig. 7 (lower "Lincoln formation," Gibson Creek, Grays Harbor Co., Wash.).

Specimens from Gries Ranch closely resemble the form figured by Van Winkle, which came from the lower beds of the "Lincoln horizon" of Gibson Creek, U.W. Loc. 367. Although this species occurs rarely in the beds at the old Gries Ranch, it is common at Loc. A-1424, about one-half mile south of Gries Ranch in beds of the same horizon.

Genus MACOMA Leach, 1819

Genotype, *Macoma tenera* Leach.

MACOMA sp.

This species is represented by two poorly preserved specimens which do not allow specific determination. The hinge is clearly of a macomoid type and the outline, as shown by growth lines, is similar to *M. lorenzoensis* (Arnold) (1908, p. 367, pl. 33, fig. 1, San Lorenzo formation, Oligocene, Santa Cruz quad., Calif.).

Family SEMELIDAE

Genus SEMELE Schumacher, 1817

Genotype, *Tellina reticulata* Spengler.

SEMELE REAGANI Dickerson

Semele reagani DICKERSON, *1917*, pp. 170, 171, pl. 29, figs. 1*a*–1*d*.

Semele gayi Arnold, DICKERSON, *1917*, pl. 29, figs. 2*a*, 2*b*.

The specimen figured by Dickerson as *S. gayi* is about one-half the size of the mature *S. reagani*, and differs only in its slightly more attenuate anterior end, a variable character in this species, especially in the immature forms.

Family SOLENIDAE

Genus SOLEN Linné, 1758

Genotype, *Solen vagina* Lamarck.

SOLEN TOWNSENDENSIS Clark

Solen (*Plectosolen*) *townsendensis* CLARK, *1925*, p. 97, pl. 22, figs. 7, 10 (lower Oligocene (?), Skamakawa River, Wakhiakum Co., Wash.; and Oak Bay, one-half mile south of Portage, Port Hadlock Co., Wash.).

Solen lincolnensis Weaver, DICKERSON, *1917*, p. 160.

Although the type and paratype of *S. townsendensis* are much smaller than the specimens from Gries Ranch, additional material from the type locality shows an approach to the latter in size. They are very similar in outline and shape and the anterior sulcus in both is represented only by a slight broad depression in the

EXPLANATION OF PLATE 46

FIGS. *1, 2—Barbatia* (*Acar*) *reinharti* Effinger, n. sp. (×2.4). Holotype, 33,504. (p. 367)

3, 4, 7—Mya (*Antiguamya*) *arnoldi* (Dickerson) (×2.4). *3*, Hypotype, 33,540; *4*, hypotype, 33,542; *7*, hypotype, 33,541. (p. 373)

5—Nuculana merriami (Dickerson) (×4.2). Hypotype, 33,509. (p. 366)

6—Cucullaria (*Porterius*) *gabbi* (Dickerson) (×2.4). Hypotype, 32,429. (p. 366)

8—Arca washingtoniana Dickerson (×3.6). Hypotype, 33,503. (p. 367)

9, 10—Chama grunskyi Hanna (×3). *9*, Hypotype, 33,519; *10*, hypotype, 33,518. (p. 369)

11—Cardita (*Carditamera*) *weaveri* Dickerson (×2.4). Hypotype, 33,523. (p. 369)

12, 16—Spirotropis (*Spirotropis*) *winlockensis* Effinger, n. sp. (×2.4). Holotype, 33,607. (p. 386)

13, 17, 20—Odostomia (*Odostomia*) *winlockiana* Effinger, n. sp. *13, 17*, Holotype, 33,565; *13*, enlargement showing nucleus. *17*, (×9.7); *20*, paratype, 14,882 (×4.8). (p. 375)

14—Tellina (*Tellina*) *townsendensis* Clark (×1.2). Hypotype, 32,722. (p. 371)

15, 21—Liotia weaveri Effinger, n. sp. Holotype 33,556. *15*, (×7.2); *21*, (×11). (p. 374)

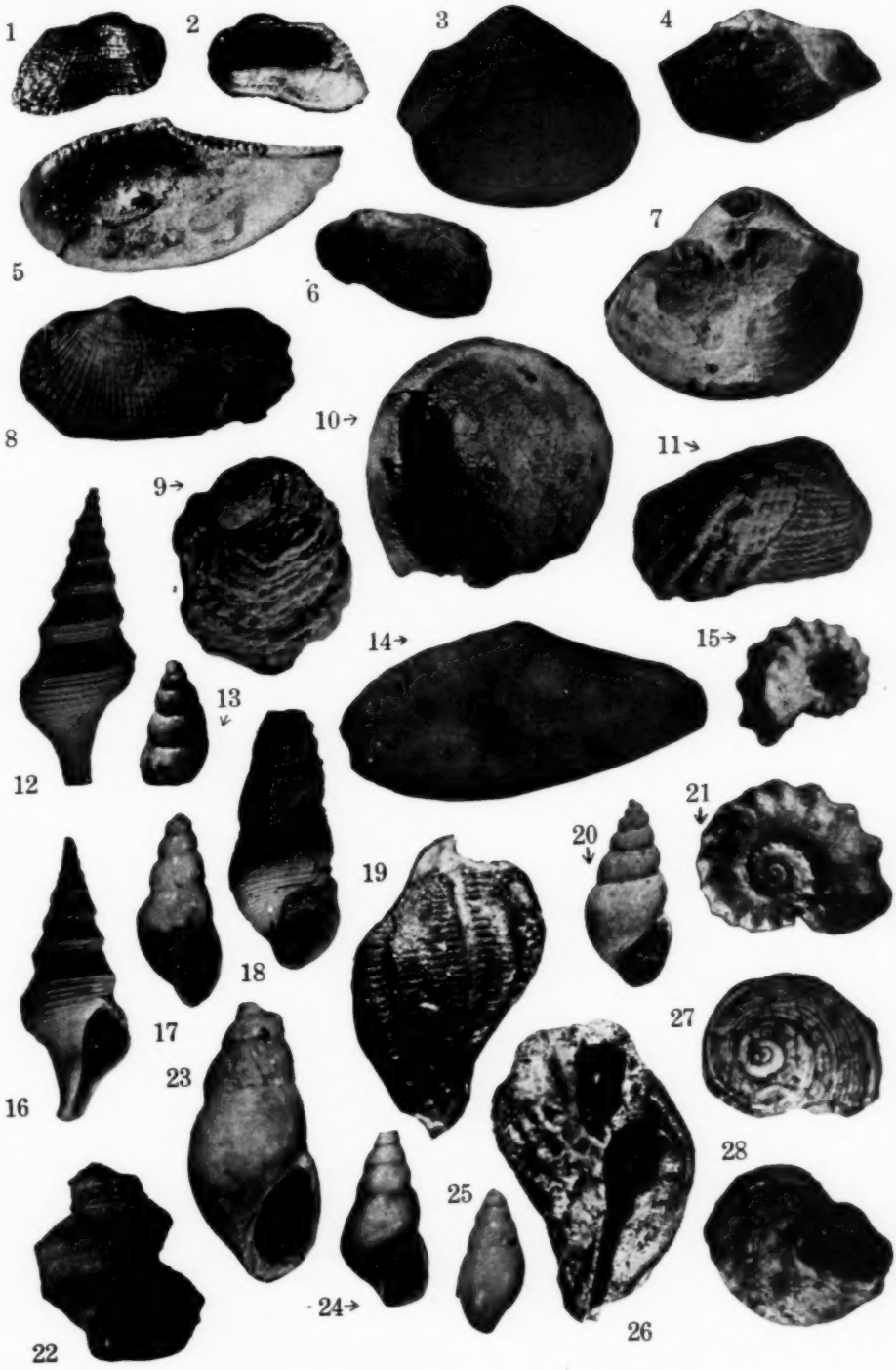
18—Elimia n. sp. (×2.4). Hypotype, 33,585. (p. 379)

19, 26—Urosalpinx n. sp. (×2.4). Hypotype, 33,596. (p. 383)

22—Trichotropis alienensis Effinger, n. sp. (×4.8). Holotype, 33,586. (p. 381)

23–25—Odostomia griesensis Effinger, n. sp. *23, 25*, Paratype, 14,810. *23*, (×20); *25*, (×4.8); *24*, holotype, 33,564 (×9.7). (p. 375)

27, 28—Cirsochilus washingtonianus Effinger, n. sp. (×8.5). Holotype, 33,553. (p. 374)



Effinger, Tertiary Pelecypods and Gastropods

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shell, the trend of which is at right angles to the dorsal margin.

S. townsendensis differs from *S. lincolnensis* Weaver (1916a, p. 43, pl. 2, figs. 9–12), from the Lincoln zone, in having the posterior ventral margin rounded instead of square, and in lacking the prominent, deep, anterior sulcus. Closely related forms occur in the Pittsburg Bluff beds, Columbia County, Ore., and in the San Emigdio formation of California.

Family MACTRIDAE

Genus SPISULA Gray, 1837

Genotype, *Cardium solidum* Linné.

SPISULA PACKARDI Dickerson

Spisula packardi DICKERSON, *1917*, pp. 169, 170, pl. 28, figs. 5*a*, 5*b*; ?WAGNER and SCHILLING, pp. 243, 244 (San Emigdio formation).

Numerous excellently preserved specimens of *S. packardi* have been obtained from the type locality. These show marked variation in shape, grading from the most common variety, almost equilateral in outline and moderately high, to an attenuate form, in which the anterior end is much longer than the posterior.

S. packardi has been listed by Wagner and Schilling (1923, p. 244) from the San Emigdio formation of California. Examination of numerous specimens in the Wagner and Schilling collection reveals that some specimens are extremely close to the Gries Ranch forms. However, the anterior and posterior dorsal areas slope much more steeply to the valve margin.

Family MYACIDAE

Genus MYA (Linné) Lamarck, 1799

Genotype, *Mya truncata* Linné.

Subgenus ANTIGUAMYA, n. subgen.

Genotype, *Mya* (*Antiguamya*) *arnoldi* (Dickerson)

MYA (ANTIGUAMYA) ARNOLDI (Dickerson)

Plate 46, figures 3, 4, 7

Saxicava arnoldi DICKERSON, *1917*, p. 171, pl. 29, figs. 5*a*, 5*b*.

The structure of the hinge is typical of the genus *Mya;* however, the shorter shell, the marked umbonal grooves, and the constricted gape exclude this species from *Mya* s. s. These differences are of sufficient importance to separate this form from other described groups of Myas and a new subgenus has been erected for it.

This species seems to be closely related to "*Corbula*" *stillwaterensis* Weaver and Palmer (1922, p. 25, pl. 8, fig. 14), from the Cowlitz formation, McClarety Ranch. This appears to be the oldest occurrence of the genus *Mya* and, although it is not the typical, may represent an ancestral form.

Family CORBULIDAE

Genus CORBULA Bruguière, 1797

Genotype, *Corbula sulcata* Bruguière.

CORBULA COWLITZENSIS Dickerson

Corbula cowlitzensis DICKERSON, *1917*, pp. 168, 169, pl. 28, figs. 3*a*–3*c*; VAN WINKLE, *1918*, p. 75.

The Gries Ranch species seems to be most closely related to *C. dickersoni* Weaver and Palmer (1922, pp. 24, 25, pl. 9, figs. 9, 10), from the Cowlitz Eocene, but differs in its greater degree of tumidity and in its smaller size. The concentric ribbing on *C. cowlitzensis* consists of rather broad concentric undulations of round-topped ribs and U-shaped grooves, while *C. dickersoni* has more numerous, slightly flat-topped ribs alternating with U-shaped grooves.

Family GARIDAE

Genus GARI Schumacher, 1827
(= PSAMMOBIA Lamarck)

Genotype, *Gari vulgaria* Schumacher.

GARI MARTINI (Dickerson)

Psammobia martini DICKERSON, *1917*, p. 168, pl. 27, figs. 7*a*, 7*b*.

G. martini closely resembles *G. columbiana* (Weaver and Palmer) (1922, p. 22, pl. 10, fig. 18), from the Cowlitz formation, but the ligamental groove and flange above it seem to be much more prominently developed than in the latter species.

Class GASTROPODA

Family ACMAEIDAE

Genus ACMAEA Eschscholtz, 1830

Genotype, *Acmaea mitra* Eschscholtz.

ACMAEA OCITATIA Hanna

Acmaea ocitatia HANNA, *1924*, p. 156.
Patella subquadrata DICKERSON, *1917*, p. 182, pl. 31, figs. 13*a*, 13*b*.

Dickerson's designation was a homonym of a species previously described by Dunker (1847, p. 113, pl. 13, fig. 18). The Gries Ranch species was later renamed by Hanna.

Acmaea ocitatia may be distinguished from *A. simplex* Dickerson, with which it occurs, by its more centrally placed apex and by the presence of radiating ribs. *A. oakvillensis* Van Winkle (1918, p. 84, pl. 7, fig. 18), from the "*Barbatia merriami* zone," Oakville, Wash., may be conspecific, but the material upon which this species is based is poorly preserved.

ACMAEA SIMPLEX Dickerson

Acmaea simplex DICKERSON, *1917*, p. 181, pl. 31, figs. 11*a*, 11*b*.
Acmaea clarki VAN WINKLE, *1918*, p. 85, pl. 6, fig. 4 (Oakville Quarry, Wash.).

The type of *A. clarki* is an internal mold slightly larger than *A. simplex* but otherwise indistinguishable.

Family TURBINIDAE

Genus CIRSOCHILUS Cossmann, 1888

Genotype, *Delphinula striata* Lamarck. Eocene Lutetian, Paris Basin.

CIRSOCHILUS WASHINGTONIANUS
Effinger, n. sp.
Plate 46, figures 27, 28

Shell small, turbinate, spire low, number of whorls four; nuclear whorls flat, consisting of about one and one-half volutions; body whorl comparatively large, tricarinate; suture linear, distinct, lying directly upon the middle carina of the preceding whorl; upper surface of body whorl flat, ornamented by eight distinct, incised spiral lines separated by flat areas which are slightly wider toward the suture than those near the carina; surface between upper and medial carinae narrow, concave, bearing three small rounded revolving ribs; surface between medial and lower carinae slightly less concave than that directly above and ornamented by three similar ribs; lower surface of body whorl only moderately convex, broad, ornamented by eleven incised spiral striae, which become more closely spaced progressively toward the outer margin; umbilicus narrow, deep; aperture rounded, incised, posterior margin protruding farther than anterior; outer lip thin, lower inner lip thick, parietal wall lacking a noticeable deposit of callus; longitudinal ornamentation consisting only of fine, somewhat sinuous incremental lines. Dimensions: holotype 33,553, altitude 2.2 mm, maximum diameter 3 mm.

Genus HOMALOPOMA Carpenter, 1864

Genotype, *Turbo sanguinea* Linné. Recent, Mediterranean.

HOMALOPOMA? sp.

Imperfect specimens only have been obtained from Gries Ranch. These seem to compare with *H. wattsi* (Dickerson) (1916, p. 494, pl. 40, figs. 3*a*, 3*b*, Eocene of Marysville Buttes, Calif.; also occurs in Cowlitz formation), but have a slightly lower spire and coarser spiral ribs. A similar form occurs at Woodman Station.

Family LIOTIIDAE

Genus LIOTIA Gray, 1847

Genotype, *Delphinula cancellata* Gray.

LIOTIA WEAVERI Effinger, n. sp.
Plate 46, figures 15, 21

Shell small, thin, planorboid, three and one-half to four whorls, increasing uniformly in size; upper surface flat, suture distinct; umbilicus broadly open, extending up to the nuclear whorls, columellar wall turreted; nuclear whorls about one and one-half, smooth; aperture holostomate, round, very slightly flaring, subhexagonal in outline, internally nacreous; ornamentation of body whorl consisting of six spiral ribs, two promi-

nent ribs forming upper and lower angulation of the whorl respectively, between which are two slightly less prominent ribs; two less conspicuous spiral ribs lie on the umbilical slope, one located medially on this surface, the other forming the umbilical margin; longitudinal ornamentation consisting of sixteen longitudinal ribs especially prominent on the peripheral portion of the whorl, becoming obscure on the inner surface of the whorl; prominent rounded nodes formed at juncture of the longitudinal ribs and angulation; whorls also sculptured by numerous fine, slightly sinuous, regularly spaced longitudinal riblets which are more strongly developed on the peripheral region. Dimensions: holotype 33,556, altitude 1.3 mm, maximum diameter 2.4 mm.

Family PYRAMIDELLIDAE

Genus ODOSTOMIA Fleming, 1817

Subgenus ODOSTOMIA

Genotype, *Turbo plicatus* Montagu.

ODOSTOMIA (ODOSTOMIA) WINLOCKIANA Effinger, n. sp.

Plate 46, figures 13, 17, 20

Shell small, elongate-conic; whorls five, with white polished surface; nuclear whorls small, heterostrophic, mounted at an angle of about 45° to the main axis of coiling, deeply immersed; post-nuclear whorls gently convex, upper portion of each whorl somewhat appressed immediately below the suture; body whorl of slightly greater altitude than the spire, broadly and evenly rounded and slightly inflated; aperture suboval, outer lip thin, anterior portion slightly flaring; lower portion of inner lip free, giving the appearance of a slight umbilical fissure; columella with a single fold, which is generally obsolete as seen from the unbroken aperture; ornamentation consisting of microscopic incremental lines only. Dimensions: holotype 33,565, altitude 3.1 mm, altitude of spire 1.4 mm, maximum diameter 1.3 mm, apical angle 25°; paratype 14,882.

Subgenus EVALEA A. Adams, 1860

Genotype, *Evalea elegans* Adams.

ODOSTOMIA (EVALEA) HILTONI (Van Winkle)

Plate 47, figures 4, 5

Eulima hiltoni VAN WINKLE, *1918*, pp. 85, 86, pl. 7, fig. 12.

Shell minute, somewhat fusiform, whorls five, smooth, vitreous, slightly convex, somewhat turreted by the deeply appressed suture. Body whorl generally a little more than half the total altitude of the shell. Aperture elongate, melanelliform, narrowing gradually to an acute angle above, abruptly rounded below; inner lip bearing a thin deposit of callus in the parietal region; columella with a distinct fold visible from the aperture. Nuclear whorls greatly tilted and deeply immersed in the spire, heterostrophic. Ornamentation consists of very faint incremental lines and microscopic spiral threads.

A study of all the collections of Gries Ranch material available has failed to reveal any specimen with the combined characters of aperture and spire as stated in the original description of this species. However, in some 18 specimens found from the type locality the spire agrees perfectly with that of the type figure, but the characters of the aperture are markedly different. Since the type specimen lacks the aperture and greater part of the body whorl, the description of these characters being taken from "other specimens," it seems probable that the original description was based upon two distinctly different forms. The characters of the spire are those of the figured specimen, the characters of the aperture are probably those of one of the Melanellas. Unfortunately the type is lost, but it seems reasonably certain that the topotype here figured is specifically identical with the type figure of "*Eulima*" *hiltoni*. If the type is not rediscovered, it may be made the neotype.

ODOSTOMIA GRIESENSIS Effinger, n. sp.

Plate 46, figures 23–25

Shell small, heavy, somewhat rugose,

imperforate, whorls five; spire high, narrow; nuclear whorls mounted at right angles to axis of spire, deeply immersed, unornamented; post-nuclear whorls very slightly convex; suture linear, slightly appressed; body whorl moderately large, evenly convex; aperture subovate; outer lip simple, anterior portion slightly elongate, alate; parietal portion of inner lip covered by a moderate deposit of callus; lower portion of inner lip slightly excavated; columellar plait small; ornamentation consisting only of retractive lines of growth. Dimensions: holotype 33,564, altitude 3 mm, height of spire 1.4 mm, maximum diameter 1.2 mm; paratype 14,810, altitude 2 mm, maximum diameter 1.2 mm.

This species may be distinguished from *O. winlockiana*, n. sp., by its less convex whorls lacking the strongly impressed suture, imperforate umbilicus, excavated lower inner lip, and slightly different proportions.

Family MELANELLIDAE

Genus MELANELLA Bowditch, 1822
Subgenus MELANELLA s. s.
Section EULIMA Risso, 1826

Genotype, *Eulima elegantissima* Risso (= *Turbo politus* Linné).

MELANELLA (MELANELLA) CLARKI (Dickerson)

Eulima clarki DICKERSON, *1917*, pp. 179, 180, pl. 31, fig. 8; VAN WINKLE, *1918*, p. 76.
Eulima smithi VAN WINKLE, *1918*, pl. 7, fig. 22; GRANT and GALE, *1931*, p. 864 (stated to be not a *Melanella*).
Pyramidella? praecursor HANNA, *1924*, pp. 178, 179; GRANT and GALE, *1931*, p. 864, footnote (3).

A study of some 300 specimens from the type locality indicates considerable variation within this group. The typical form is slender, with slightly rounded whorls, and shows a slight angulation on the base of the body whorl, below which may be several spiral ribs. The typical form grades into a more elongate variety with rounded body whorl and more prominent canal, as well as into a short, conical, flat-whorled variety with a strongly angulate body whorl. The latter variety was designated *Eulima smithi* by Van Winkle, a name used previously by Reagan (1922, p. 223) and therefore renamed by Hanna. Since these varieties occur together, they are not known to have any stratigraphic significance, and as they are traceable by numerous gradations into one another, there seems to be no practical reason for applying more than one taxonomic designation to what appears to be a single somewhat variable species.

MELANELLA sp.

Several imperfectly preserved specimens, apparently belonging to a single species of *Melanella*, were obtained from Loc. 3,607. The shell is vitreous, straight-spired and has about eight flat-sided whorls; the suture is linear and but slightly impressed. The shape and character of the whorls of the spire resemble those of *M. oldroydi* Bartsch (1917, p. 309, pl. 36, figs. 5–7), a Recent Pacific Coast species.

Family EPITONIIDAE

Genus EPITONIUM ("Bolten") Roeding
Subgenus BOREOSCALA Kobelt, 1907

Genotype, *Epitonium greenlandicum* (Perry). Living.

EPITONIUM (BOREOSCALA) CONDONI Dall

Epitonium (*Arctoscala*) *condoni* DALL, *1909*, p. 53, pl. 3, figs. 1, 12 (from Oligocene of Eugene, Ore.); WAGNER and SCHILLING, *1923*, pp. 243–244 (San Emigdio formation, Oligocene); SCHENCK, *1928*, pp. 11, 15 (Oligocene, Eugene, Ore.).

The Gries Ranch specimens differ from the type of *Epitonium condoni* Dall in having fewer varices (12 on the Gries Ranch form, 15 on the typical); in possessing slightly more tumate whorls; and in the presence of a moderately well-defined basal plate.

Genus ACRILLA H. Adams, 1860
Subgenus FERMINOSCALA Dall, 1908

Genotype, *Acrilla ferminiana* (Dall). Recent, Gulf of Panama to California.

ACRILLA (FERMINOSCALA) DICKERSONI Durham

Acrilla (*Ferminoscala*) *dickersoni* DURHAM, *1937*, p. 508, pl. 57, figs. 12, 13.

Epitonium washingtonensis Weaver, DICKERSON, *1917*, pp. 160, 161, pl. 31, figs. 7*a*, 7*b*.

Acrilla dickersoni Durham is closely related to a form occurring in the lower Oligocene beds north of Woodman Wharf, Discovery Bay, Wash., which seems to differ only in number and spacing of the varices, distinctions probably of not more than varietal importance.

Family ?EPITONIIDAE

Genus ?TURRITELLOPSIS Sars, 1878

Genotype, *Turritellopsis acicula* (Stimpson). Recent, North Atlantic.

TURRITELLOPSIS? WEAVERI (Van Winkle)

Plate 47, figures 6, 7

Turritella weaveri VAN WINKLE, *1918*, p. 87, pl. 7, fig. 14.

Turritellopsis weaveri has a striking similarity to *T. acicula* (Stimpson) (1878, p. 186; Tryon, 1886, p. 193). The spiral and longitudinal sculpturing are similar, and both have a deep sutural groove. The nuclear whorls of the Gries Ranch form are almost planispiral while those of the genotype are somewhat more elevated.

The present distribution of this genus is circumboreal. The only known fossil occurrence of this genus on the West Coast is from the upper Pleistocene at San Quentin Bay, Lower California, Mexico (Grant and Gale, 1931, p. 776, *T. acicula* (Stimpson) var. *stimpsoni* Dall).

Family NATICIDAE

Genus NATICA Scopoli, 1777

Genotype, *Natica vitellus* Linné.

NATICA (NATICA) cf. WEAVERI Tegland

Natica (*Natica*) *weaveri* TEGLAND, *1933*, pp. 138, 139, pl. 14, figs. 13–17 (type Lincoln zone).

This species is extremely rare in the Gries Ranch fauna, represented in the collections by a single specimen only, which lacks the greater portion of the spire. Body whorl well preserved, and globose with an appressed suture; umbilicus luniform with a strong pillar and well-marked funicle.

Genus POLINICES Montfort, 1810

Genotype, *Polinices albus* Montfort.

POLINICES LINCOLNENSIS (Weaver)

Natica lincolnensis WEAVER, *1916*, p. 44, pl. 5, figs. 71, 72 (type Lincoln zone).

Weaver (1916a, pp. 44, 45) recognized two species of *Polinices* in the type Lincoln beds, which he designated "*Natica*" *washingtonensis* and "*Natica*" *lincolnensis*. The differentiation was based upon differences in the character of the umbilical opening, the former having a heavy deposit of callus covering over the umbilicus completely, the latter having the umbilicus widely open and traversed by a distinct ridge. In examining abundant topotype material of these species, it was observed that the majority of these specimens had the characters of either one or the other of Weaver's species, but a number of specimens showed intermediate gradations between the two. From a study of many topotype specimens, Tegland (1933, p. 139) came to the conclusion that the species were probably identical. All of the specimens found from Gries Ranch, however, have the characteristic widely open umbilicus of *P. lincolnensis*. No specimens of *P. washingtonensis* have been observed, suggesting that the umbilicate form may have a slightly longer geologic range and that the distinction between these forms is of nomenclatural importance.

Genus NEVERITA Risso, 1826

Genotype, *Neverita josephina* Risso.

NEVERITA NOMLANDI Dickerson

Neverita nomlandi DICKERSON, *1917*, pp. 173, 174, pl. 30, figs. 2*a*, 2*b*.

This species seems to be closely related to *Neverita weaveri* Dickerson (1915, p. 57, pl. 4, figs. 10*a*, 10*b*), from the Cowlitz formation. It has the same general shape of spire and body whorl and lacks the sulcus crossing the callus. The Gries Ranch form is larger and the callus never completely covers the umbilical opening, as it commonly does in the Cowlitz species.

Family CALYPTRAEIDAE

Genus CALYPTRAEA Lamarck, 1899

Genotype, *Calyptraea chinensis* Linné.

CALYPTRAEA DIEGOANA (Conrad)

Trochita diegoana CONRAD, *1855*, pp. 7, 17; *1857*, pp. 176, 319, 327, pl. 5, fig. 42.

The type of this species is believed to have come from the Eocene of San Diego, and, as Stewart (1927, pp. 340, 341) pointed out, it is probably the common Eocene *Calyptraea* so often listed as "*C. exentrica*," which occurs at almost every Eocene locality from California to Washington. The common *Calyptraea* from the Lincoln and Blakeley zones of Washington, *C. washingtoniana* Weaver, has been placed in synonymy with *C. diegoana*. Although the Lincoln species is usually more concentric and has a more nearly circular outline than the majority of the Cowlitz specimens, a great deal of variation is shown and it seems best to regard these forms as synonymous, at least for the present. Five specimens from Gries Ranch all have a concentric spire and rounded aperture similar to the common Lincoln form.

Family CREPIDULIDAE

Genus CREPIDULA Lamarck, 1799

Genotype, *Patella fornicata* Lamarck.

CREPIDULA PILEUM (Gabb)

Crypta (*Spirocrypta*) *pileum* GABB, *1864*, pp. 137, 228, pl. 29, figs. 233, *a*, *b* (Tejon Eocene, Fort Tejon).

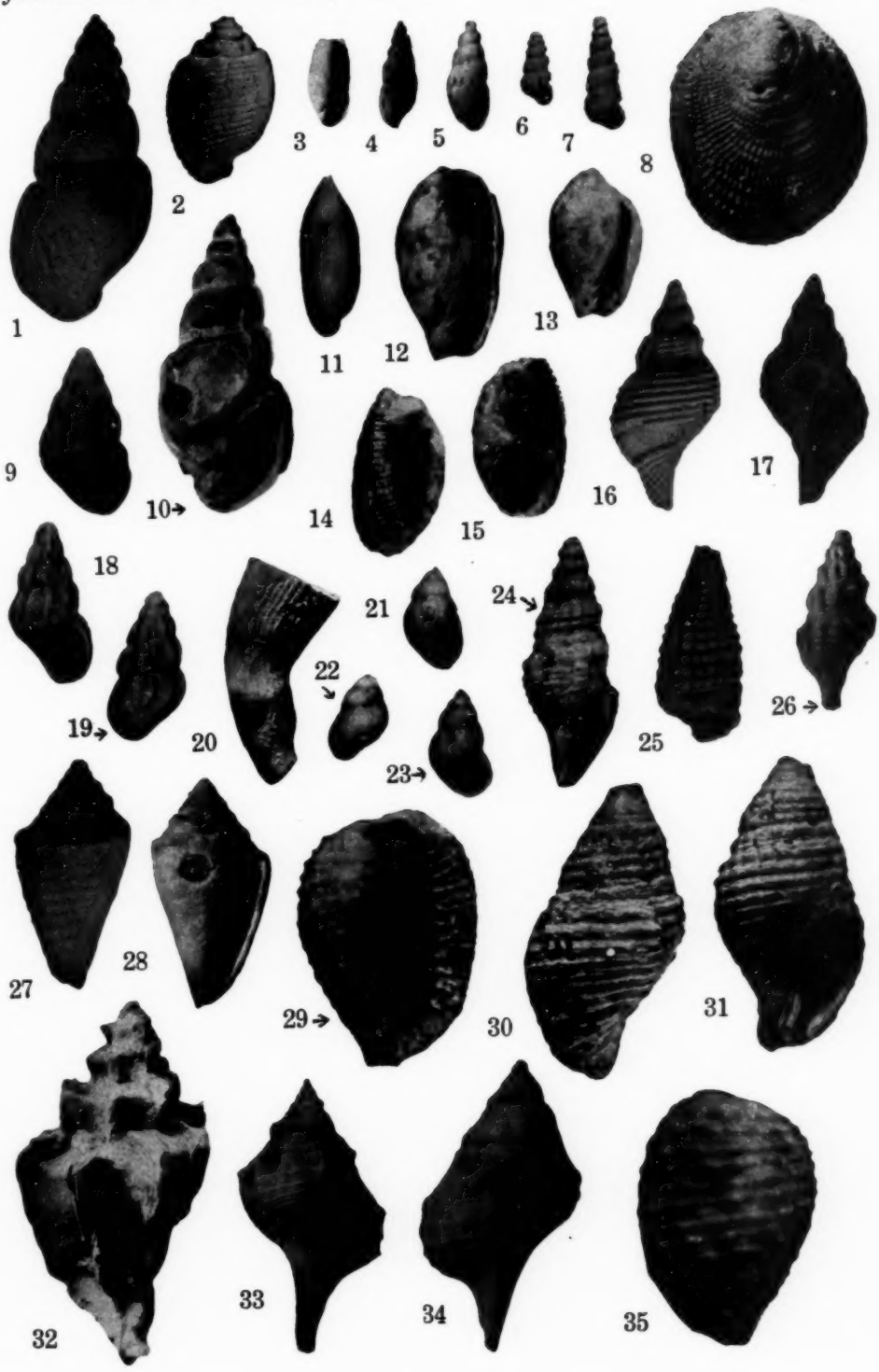
Crepidula dickersoni WEAVER and PALMER, *1922*, p. 31, pl. 11, fig. 2; pl. 12, fig. 9 (Cowlitz formation).

Crepidula pileum (Gabb), STEWART, *1927*, pp. 341, 342, pl. 29, figs. 2, 3.

Several specimens of *Crepidula* from Gries Ranch show the body whorl to have a rather marked variation in convexity. The more tumid forms are indistinguishable, both in external appearance and in shape and character of the septum, from variants from the Cowlitz formation which have been referred to this species.

EXPLANATION OF PLATE 47

FIGS. *1*, *10*—*Molopophorus bramkampi* Effinger, n. sp. (×2.4). Holotype, 33,592. (p. 383)
2—*Acteon parvum* Dickerson (×2.7). Hypotype, 33,613. (p. 387)
3—*Cylichnina turneri* Effinger, n. sp (×4.8). Holotype, 33,619. (p. 387)
4, *5*—*Odostomia* (*Evalea*) *hiltoni* (Van Winkle) (×4.8). Hypotype, 33,562. (p. 375)
6, *7*—*Turritellopsis? weaveri* (Van Winkle) (×4.8). *6*, Hypotype, 14,806; *7*, hypotype, 33,572. (p. 377)
8—*Hipponix arnoldi* Dickerson (×3). Hypotype, 33,575. (p. 379)
9, *18*, *19*—*Turbella cowlitzensis* Effinger, n. sp. *9*, Holotype, 33,557 (×7.2); *18*, paratype, 33,826 (×7.2); *19*, paratype, 14,819 (×2.4). (p. 379)
11—*Volvulella tabori* Effinger, n. sp. (×9.7). Holotype, 33,612. (p. 387)
12—*Marginella* n. sp. (×4.8). Hypotype, 14,831, Loc. A-364; figured for comparison. (p. 385)
13—*Marginella* (*Cryptospira?*) *instabilata* Hanna (×9.7). Hypotype, 33,604. (p. 384)
14, *15*—*Scaphander washingtonensis* sub-sp. *goodspeedi* Effinger, n. sub-sp. (×6). Holotype, 33,611. (p. 387)
16, *17*—"*Fusinus*" *gesteri* Dickerson (×2.4). Hypotype, 33,601. (p. 384)
20—*Balanophyllia* cf. *variabilis* Nomland (×2.4). Hypotype, 15,384. (p. 388)
21, *22*, *23*—*Alvania lettana* (Van Winkle) (×7.2). *21*, *22*, Hypotype, 33,552; *23*, hypotype, 33,551. (p. 379)
24, *26*—*Clavatula arnoldi* (Van Winkle). *24*, Hypotype, 33,608 (×12); *26*, hypotype, 33,609 (×3.6). (p. 386)
25—*Cerithiopsis washingtoniana* (Dickerson) (×2.4). Hypotype, 33,584. (p. 380)
27, *28*—*Conus ruckmani* Dickerson (×2.4). Hypotype, 33,624. (p. 385)
29, *35*—*Cypraeogemmula warnerae* Effinger, n. sp. (×9.7). Holotype, 33,588. (p. 381)
30, *31*—*Cominella eocenica* (Weaver) (×3). Hypotype, 33,593. (p. 384)
32—*Trophon calamitus* (Hanna) (×2.4). Hypotype, 33,615. (p. 382)
33, *34*—*Whitneyella gabbi* (Dickerson) (×1.2). *33*, Hypotype, 33,594; *34*, hypotype, 33,595. (p. 384)



Effinger, Tertiary Gastropods

UNIV. OF MICH.

Family HIPPONICIDAE

Genus HIPPONIX de France, 1819

Genotype, *Patella cornucopia* Lamarck. Eocene, Paris Basin.

HIPPONIX ARNOLDI Dickerson

Plate 47, figure 8

Hipponix arnoldi DICKERSON, *1917*, pp. 180, 181, pl. 31, figs. 10*a*–10*d*; VAN WINKLE, *1918*, p. 76.

Hipponix ornata DICKERSON, *1917*, p. 181, pl. 31, figs. 12*a*, 12*b*; VAN WINKLE, 1918, p. 76.

The two species of *Hipponix* described from Gries Ranch by Dickerson represent two extremes of variation in a perfectly grading series, and, therefore, seem to represent only a single somewhat variable species. The position of the apex varies from subcentral to protruding behind. The ornamentation varies from fine radial striations to well-marked radiating ribs, which are crossed by incremental lines varying in prominence from fine to rugose, producing a "shingled" appearance.

H. arnoldi rather closely resembles *H. barbatus* Sowerby, a living West Coast species.

Family LITTORINIDAE

Genus LITTORINA Ferussac, 1882

Genotype, *Littorina littoralis* Linné.

LITTORINA OLIGOCENICA Dickerson

Littorina oligocenica DICKERSON, *1917*, p. 178, pl. 31, fig. 1.

This species is very abundant at the type locality. The numerous specimens obtained show a great deal of variation in shape from conic to more elongate. The species may be distinguished from *L. mountsoloensis* Weaver and Palmer (1922, p. 30, pl. 11, fig. 12), from the Cowlitz formation, by the more tumid shape of the latter.

Family RISSOIDAE

Genus ALVANIA (Leach) Risso, 1826

Genotype, *Turbo cimex* Linné. Recent.

ALVANIA LETTANA (Van Winkle)

Plate 47, figures 21–23

Rissoa lettana VAN WINKLE, *1918*, pp. 86, 87, pl. 7, fig. 13.

This species closely resembles *A. acutilirata* (Carpenter), a Recent species from the San Diego Coast, but may be distinguished by its greater number of revolving threads and longitudinal ribs. *A. vinosula* Anderson and Hanna (1925, pp. 131, 132, pl. 14, figs. 5, 6), from the type Tejon of California, differs from the Gries Ranch species in having a subquadrate aperture and in that the longitudinal ribs extend farther down on the body whorl.

Genus TURBELLA Leach in Gray, 1847

Genotype, *Rissoa parva* Da Costa. Living.

TURBELLA COWLITZENSIS Effinger, n. sp.

Plate 47, figures 9, 18, 19

Shell minute, heavy, conical, whorls six; post-nuclear whorls moderately convex; base of body whorl indistinctly angulated; aperture subovate; outer lip evenly rounded, joining the parietal region above to form an acute angle; inner lip bearing a moderately heavy callus; lower portion of aperture abruptly rounded at juncture of inner and outer lip; outer lip thickened a short distance back of aperture; ornamentation consisting of prominent, evenly spaced, protractive axial ribs, which number eleven on the body whorl, not extending below the angulation. Dimensions: holotype 33,557, altitude 3 mm, maximum diameter 1.5 mm; paratype 33,826, altitude 2.7 mm, maximum diameter 1.4 mm; paratype 14,819. So far as I have been able to discover, the only other reported occurrence of this genus on the West Coast is *Turbella elegans* Palmer (1923, pp. 299, 300, pl. 52, figs. 2–4), from the middle Eocene shales near Vacaville, Calif. *T. cowlitzensis* lacks the spiral ribbing which is present on the genotype.

Family PLEUROCERIDAE

Genus ELIMIA H. and A. Adams, 1854

Genotype (see Stewart, 1927), *Melania acutocarinata* Lea.

ELIMIA n. sp.

Plate 46, figure 18

A single specimen of *Elimia*, lacking the upper portion of the spire and a

small portion of the outer lip, is represented in the collections from Gries Ranch. However, the specimen seems to represent a form distinct from any described from the West Coast. It is probably related to *E. lewisiana* (Weaver) (1912, p. 37, pl. 2, figs. 22, 25), from the Cowlitz formation near Vader, Wash., but lacks the strong spiral and longitudinal ornamentation of that species. The Gries Ranch specimen has very slightly convex whorls, the upper part of which, directly below the suture, are ornamented with 25 rather obsolete longitudinal ribs. The spiral ornamentation consists of about 24 flat-topped revolving threads on the body whorl, those of the upper surface of the whorl producing cancellations with the longitudinal ribs, becoming less distinct on the central portion of the whorl, and again conspicuous on the lower portion of the body whorl. The suture is slightly appressed and somewhat sinuous. Dimensions: hypotype 33,585, altitude (incomplete) 14.1 mm, maximum diameter 5.8 mm, apical angle (approximately) 16°.

Family CERITHIIDAE

Genus BITTIUM (Leach) Gray, 1847

Genotype, *Murex reticulatus* Montagu (=*Strombimormis reticulatus* Da Costa). Recent, European seas.

BITTIUM HOWARDI (Dickerson)

Cerithiopsis howardi DICKERSON, *1917*, p. 175, pl. 30, figs. 6*a*, 6*b*.
Cerithiopsis fasteni VAN WINKLE, *1918*, pp. 87, 88, pl. 7, fig. 8.

This species is exceedingly abundant at Gries Ranch, where collecting has yielded several hundred well-preserved specimens. From a study of this material there seems to be no basis for the separation of two species. The type of *Bittium fasteni* should be in the University of Washington collections, but cannot be located. The figure and dimensions of the type would indicate a less mature individual than the type of *B. howardi*. The only important difference suggested by comparing the descriptions of these two forms is that the base of the body whorl of *B. howardi* is stated to be smooth. The presence of fine but distinct spiral threads on this portion of the shell on all well-preserved specimens suggests that the specimen figured by Dickerson may have suffered some erosion.

Family CERITHIOPSIDAE

Genus CERITHIOPSIS Forbes and Hanley

Genotype, *Murex tubercularia* Montagu.

CERITHIOPSIS MERRIAMI (Dickerson)

Epitonium merriami DICKERSON, *1917*, pp. 175, 176, pl. 30, figs. 7*a*, 7*b*; VAN WINKLE, *1918*, p. 76.

This species is congeneric with, and closely resembles "*Melania*" *vaderensis* Dickerson (1915, pp. 60, 61, pl. 6, fig. 7), from the Cowlitz formation. The Gries Ranch species may be easily distinguished, for it has only three spiral ribs above the angulation while the Cowlitz species has four; and the basal plate has six to eight spiral ribs, the Cowlitz form only three.

CERITHIOPSIS WASHINGTONIANA (Dickerson)

Plate 47, figure 25

Triforis washingtoniana DICKERSON, *1915*, p. 63, pl. 6, fig. 13 (Cowlitz formation).
Triforis martini DICKERSON, *1917*, p. 176, pl. 30, fig. 9.

This species clearly does not belong to the genus *Triforis*, which is characterized by a sinistral spire, a closed aperture and a canal with three tubercles.

A direct comparison of the types of "*Triforis*" *washingtoniana* and "*Triforis*" *martini* has revealed no important differences in the characters of these two forms, and there seems to be no basis for their separation.

Family STROMBIDAE

Genus TEREBELLUM (Klein, 1753) Lamarck, 1799

Genotype, *Terebellum subulatum* Lamarck. Recent, South Pacific.

TEREBELLUM ANDERSONI (Dickerson)

Seraphs andersoni DICKERSON, *1917*, p. 180, pl. 31, figs. 9*a*, 9*b*; VAN WINKLE, *1918*, p. 76.

As was pointed out by Dickerson, *S. andersoni* is much more tumid than

"*Seraphs*" *erraticus* (Cooper), a common species in the Domengine beds of California. Since the spire is distinctly exposed on both the Gries Ranch and Domengine forms they should be referred to the genus *Terebellum* rather than *Seraphs*. The type of *Seraphs* is "*Terebellum*" *convolutum* Lamarck, from the Lutetian of Paris Basin. A specimen of *Terebellum* from the "lower Oligocene" of Woodman Wharf probably belongs to this species.

Family CYPRAEIDAE

Genus CYPRAEOGEMMULA Vredenburg, 1920

Genotype, *Cypraeogemmula liliputana* Schilder (=*Trivia scabriuscula* Koenen). Oligocene of Lattorf, Germany.

CYPRAEOGEMMULA WARNERAE Effinger, n. sp.

Plate 47, figures 29, 35

Shell minute, somewhat pyriform, globular; outline from dorsal or ventral aspect asymmetrical in relation to anteroposterior axis; margin of outer lip evenly rounded, opposite side convex above but straight to slightly concave below. Aperture somewhat cassiform, narrowing above and terminating in a short but deep posterior canal, which is strongly reflected toward the spire, widening slightly below and terminating in a straight deep anterior canal. Outer lip sharply inflected, slightly wider above than below and ornamented by about 28 prominent transverse ridges, most of which extend completely across inflected surface, giving rise to a denticulated inner margin. Inner lip demarked by a prominent longitudinal ridge extending across the body whorl from tip of anterior to tip of posterior canal; surface widest in central portion of shell, concave especially below; ornamented by 20 prominent transverse ribs similar to outer lip. Fossula obsolete; spire visible, consisting of about four whorls; nuclear whorls small, naticoid, smooth, consisting of about one and one-half volutions. Body whorl conspicuously ornamented by about 24 strong, rounded, somewhat nodose revolving ribs, which are strongest in the central portion of the whorl, becoming finer on anterior and posterior areas; interspaces wide and generally bearing a smooth interrib. Ornamentation continuous over entire dorsal surface, there being a complete absence of any longitudinal dorsal groove. Dimensions: holotype 33,588, altitude 4.1 mm, maximum diameter 3 mm. This species is named in honor of my wife, Mary Warner Effinger, for her help in preparing the manuscript.

The genus *Cypraeogemmula* was erected by Vredenburg (1920, p. 114) for a single species, *Trivia scabriuscula* von Koenen, from the Oligocene of Lattorf, Germany. The species here described seems to be the only other recorded occurrence of this genus.

Family TRICHOTROPIDAE

Genus TRICHOTROPIS Sowerby, 1829

Genotype, *Turbo bicarinata* Sowerby. Recent.

TRICHOTROPIS ALIENENSIS Effinger, n. sp.

Plate 46, figure 22

Shell small, thin; spire turreted, consisting of about five whorls, which increase rapidly in size; upper surface of whorls flat, smooth, markedly tabulate; body whorl sharply biangulate, each angle bearing a strong spiral cord; medial surface tapering slightly anteriorly and ornamented by two spiral threads; interspaces flat, about twice the width of spiral thread; lower surface of body whorl slightly concave, smooth; aperture subquadrate; outer lip thin; inner lip concave, covered with a thin deposit of callus; columella bearing a distinct longitudinal groove, which extends posteriorly up into a very small umbilical opening; anterior canal very short; growth lines strongly retractive on upper surface of whorl, almost perpendicular on medial surface, curved on lower surface so as to be concave posteriorly. Dimensions: holotype 33,586, altitude (incomplete) 6.6 mm, maximum diameter 5.8 mm.

The living species of this genus are almost entirely confined to arctic and boreal waters. Two species on the West Coast of North America, *T.* (*Iphinoe*) *kelseyi* Dall (1905, p. 254) and *T.* (*Provanna*) *lomana* Dall (1918, p. 7), range as far south as San Diego in fairly deep water; however, neither of these belongs to *Trichotropis* s. s. Although this form is very rare at Gries Ranch, its occurrence here with subtropical associates is puzzling.

Family CASSIDIDAE

Genus PHALIUM Link, 1807

Subgenus BEZOARDICA Schumacher, 1817

Genotype, *Buccinum areola* Gmelin (not Linné).

PHALIUM (BEZOARDICA) cf. EGBERTI Schenck

?Phalium (*Bezoardica*) *egberti* SCHENCK, *1926*, p. 80, pl. 13, fig. 7 (Woodman Wharf locality).

?Molopophorus sp., DICKERSON, *1917*, p. 160, pl. 30, fig. 12.

Material from Gries Ranch differs slightly in details of sculpture from specimens occurring at Woodman Wharf, the type locality of *P. egberti*.

Genus GALEODEA Link, 1870

Genotype, *Galeodea echinophora* (Linné).

GALEODEA DALLI Dickerson

Galeodea dalli DICKERSON, *1917*, p. 176, pl. 30, fig. 8*a* (not fig. 8*b*, a portion of the body whorl of *Siphonalia packi* Dickerson); VAN WINKLE, *1918*, p. 76.

Galeodea? dalli (Dickerson), SCHENCK, *1926*, p. 86.

?Galeodea cf. *fax* TEGLAND, *1931*, p. 412, pl. 59, figs. 4, 5.

As was previously pointed out by Tegland (1931, p. 410) in her study of Oligocene Galeodeas of Washington, the type of *Galeodea dalli* is an immature shell which lacks a portion of the body whorl. Tegland distinguished this individual from *G. fax* Tegland (1931, pp. 410–412, pl. 59, figs. 4, 5; pl. 60, figs. 5–11), from the Lincoln zone, by its having only two rows of nodes on the body whorl.

More recent collecting from Gries Ranch has provided only two additional specimens of *Galeodea*, one an immature shell slightly larger than the type but lacking part of the body whorl and canal, and the other a large individual which is even more incomplete (hypotype 33,590). The small specimen seems certainly conspecific with the type; however, a third row of nodes is beginning to develop on the body whorl. The large specimen, which shows the character of the spire and the upper portion of the body whorl, is indistinguishable from *G. fax* Tegland; however, the shell is too incomplete for positive determination. Since the apical whorls of the Lincoln form are similar to those of *G. dalli*, the finding of a mature form apparently inseparable from *G. fax* and a specimen which is somewhat intermediate between *G. fax* and *G. dalli* is strongly suggestive that the one is simply the immature, the other the mature form.

GALEODEA cf. FAX Tegland

Galeodea fax TEGLAND, *1931*, pp. 410–412, pl. 59, figs. 4, 5; pl. 60, figs. 5–11 (type Lincoln zone).

A single large specimen of *Galeodea*, which lacks the greater portion of the body whorl, has been collected from the Gries Ranch locality, the poor preservation precluding positive identification.

Family MURICIDAE

Genus TROPHON Montfort, 1810

Genotype, *Murex magellanicus* Gmelin. Recent, Straits of Magellan to Peru.

TROPHON CALAMITUS (Hanna)

Plate 47, figure 32

Murex calamitus HANNA, *1924*, p. 172.

Murex vaughani DICKERSON, *1917*, p. 174, pl. 30, figs. 3*a*, 3*b*; VAN WINKLE, *1918*, p. 76.

Dickerson's designation of this species had been previously used for a species of *Murex* by Maury (1910, pp. 143, 144), and was therefore renamed by Hanna.

T. calamitus more closely resembles some of the Recent forms such as *T.* (*Neptunea*) *peregrinus* Dall (1902, p. 543; 1921, p. 110, pl. 8, fig. 5) from

Catalina Island, Calif., than any known forms from the Eocene or Oligocene of the Pacific Coast.

Genus UROSALPINX Stimpson, 1865

Genotype, *Fusus cinereus* Say. Living, North America.

UROSALPINX n. sp.
Plate 46, figures 19, 26

Shell small, heavy; body whorl moderately convex, decorated by eight prominent longitudinal ribs, which extend the full length of the body whorl, and crossed by about 30 fine spiral ribs which are separated by peculiarly punctate narrow intercostal areas; aperture ovate; outer lip bearing about five denticles; canal moderately short, slightly reflected, umbilicus partially open; spire unknown. Dimensions: hypotype 33,596, altitude of body whorl 14.4 mm, maximum diameter 9.3 mm.

Family NASSARIIDAE

Genus MOLOPOPHORUS Gabb, 1869

Genotype, *Molopophorus striatus* (Gabb).

MOLOPOPHORUS STEPHENSONI Dickerson

Molopophorus stephensoni DICKERSON, *1917*, p. 177, pl. 30, figs. 10*a*, 10*b*.

M. stephensoni shows a wide range of variation. Some varieties of this species closely approach in character *M. gabbi* Dall (1909, p. 45, pl. 3, fig. 8) and *M. dalli* Anderson and Martin (1914, p. 78, pl. 6, figs. 7*a*, *b*), from the middle Oligocene of northwestern Oregon. The Gries Ranch form may generally be distinguished by its high spire, finer sculpturing, and characteristic cancellated sculpturing of the first few post-nuclear whorls.

MOLOPOPHORUS BRAMKAMPI Effinger, n. sp.
Plate 47, figures 1, 10

Shell small, fusiform; spire high, consisting of eight moderately convex whorls; suture linear, moderately depressed; body whorl about equal in length to spire, evenly convex; aperture fusiform; canal short, strongly reflected, deep; siphonal fasciole distinct, forming a moderately deep groove across the columella; ornamentation consisting of prominent incremental lines, which show a very slight flexure on the lower portion of the body whorl, and numerous small, slightly retractive longitudinal ribs, which become more prominent on middle whorls of spire, but are obsolete on body whorl; nuclear whorls large, turbinate, consisting of about two unornamented whorls. Dimensions: holotype 33,592, altitude 17.1 mm, maximum diameter 7.8 mm, apical angle 35°. Named in honor of Richard A. Bramkamp.

Only one specimen of this form has been obtained from the Gries Ranch locality, but the species is fairly numerous in the "lower Oligocene" beds of Classen's Wharf, Port Townsend Bay and at the Woodman Wharf locality, Port Discovery Bay, Wash. There is some variation in the height of body whorl, especially the angle at which the upper outer lip meets the body whorl.

This species seems to be most closely related to *Molopophorus bretzi* (Weaver) (1912, p. 53, pl. 2, fig. 21), from the Cowlitz formation, but has a much higher spire and more depressed suture.

Family NEPTUNEIDAE

Genus SIPHONALIA A. Adams, 1863

Genotype, *Buccinum cassidariaeformis* Reeve. Living.

SIPHONALIA PACKI (Dickerson)

Strepsidura packi DICKERSON, *1917*, pp. 177, 178, pl. 30, figs. 11*a*, 11*b*; VAN WINKLE, *1918*, p. 76.

Siphonalia packi, a fairly common species at Gries Ranch, is closely related to *Strepsidura bicarinata* Dickerson (1915, p. 66, pl. 8, figs. 1*a*–1*d*), from the Cowlitz formation locality on the Cowlitz River, 1.75 miles southeast of Vader, Wash. The lower Oligocene form is generally distinguished by its broader, less concave shoulder, heavier sutural band, shallower siphonal notch, less distinct siphonal fasciole, coarser spiral ribbing, and the occasional presence of a third

row of nodes on the body whorl. *S. packi* appears to be more distantly related to the middle Oligocene forms, *S. oregonensis* (Dall) (1909, p. 51, pl. 3, fig. 6, from Pittsburg Bluff, Ore.), and *S. washingtonensis* (Weaver) (1916a, pp. 48, 49, pl. 5, figs. 81–83, from type Lincoln zone, Galvin, Wash.).

Family BUCCINIDAE

Genus COMINELLA Gray

Genotype, *Buccinum porcatum* Gmelin. Living.

COMINELLA EOCENICA (Weaver)

Plate 47, figures 30, 31

Nassa eocenica WEAVER, *1912*, pp. 42, 43, pl. 3, fig. 32 (Cowlitz formation, Cowlitz River, Lewis County, Wash.).
Amphissa eocenica (Weaver), DICKERSON, *1915*, pl. 8, figs. *6a–6c*.
Cominella eocenica (Weaver), WEAVER and PALMER, *1922*, pp. 38, 39, pl. 12, figs. 5, 6.

This species, heretofore known only from the Cowlitz formation, is extremely scarce at Gries Ranch, only one well-preserved specimen having been found.

Family FASCIOLARIDAE

Genus FUSINUS Rafinesque, 1815

Genotype, *Murex colus* Linné. Recent, Indo-Pacific.

"FUSINUS" GESTERI Dickerson

Plate 47, figures 16, 17

Fusinus gesteri DICKERSON, *1917*, p. 179, pl. 31, fig. 4; VAN WINKLE, *1918*, p. 76.

This species is excluded from *Fusinus* s. s. by its shorter canal and larger nucleus. There are three and one-half to four nuclear whorls, which are unornamented, high, and do not increase as rapidly in size as the post-nuclear whorls. Although the shell is quite different, the nucleus resembles somewhat that of "*Latirofusus? interstriatus*" (Heilprin) as figured by Grabau (1904, pl. 17, fig. 8).

Although "*Fusinus*" *gesteri* occurs fairly abundantly at Gries Ranch, only young specimens have been obtained complete. Several large fragments of the body whorl, however, show that this shell attains a length of at least 24 mm. The broad longitudinal ribs, conspicuous on the first three post-nuclear whorls, gradually diminish in prominence and become obsolete on later whorls.

Genus WHITNEYELLA Stewart, 1927

Genotype, *Hemifusus washingtonianus* Weaver. Eocene, Washington.

WHITNEYELLA GABBI (Dickerson)

Plate 47, figures 33, 34

Fasciolaria gabbi DICKERSON, *1917*, pp. 174, 175, pl. 30, figs. *4a*, *4b*; VAN WINKLE, *1918*, p. 76.
"*Fasciolaria*" *gabbi* Dickerson, STEWART, *1927*, p. 402 [stated to be related to *Whitneyella washingtoniana* (Weaver)].

Whitneyella gabbi is closely related to *W. washingtoniana* (Weaver) (1912, pp. 46, 47, pl. 2, fig. 11; not fig. 12 which is *W. lincolnensis*), from the Cowlitz formation, Cowlitz River, near Vader, Wash., but may be distinguished by its generally heavier collar, its lack of reticulate sculpturing due to the less conspicuous growth lines, and by the less prominent longitudinal ribs which do not extend as far onto the upper surface of the body whorl. *W. gabbi* is also similar to but more easily distinguished from *W. lincolnensis* (Van Winkle) (1918, pp. 89, 90, pl. 7, fig. 10), from the type Lincoln zone. The latter species has an even more prominent collar, the area immediately anterior to it is markedly concave, and bears no trace of the longitudinal ribs, and the anterior portion of the canal is distinctly reflected.

In several respects the character of the Gries Ranch form is transitional between the Cowlitz and the Lincoln species, suggestive that these three species represent evolutionary stages in the development of a single stock.

Family MARGINELLIDAE

Genus MARGINELLA Lamarck, 1799

? Subgenus CRYPTOSPIRA Hinds, 1844

Genotype, *Marginella quinqueplicata* Lamarck. Living, Indo-Pacific.

MARGINELLA (CRYPTOSPIRA?) INSTABILATA Hanna

Plate 47, figure 13

Marginella instabilata HANNA, *1924*, p. 170; GRANT and GALE, *1931*, p. 628 (stated to be *Hyalina*, probably of the *Cystiscus* group).

Marginella pacifica DICKERSON, *1917*, p. 178, pl. 31, fig. 2; VAN WINKLE, *1918*, p. 76. Not *Marginella pacifica* Pease, *1868*, p. 280, pl. 23, fig. 20 (living).

The holotype (C.A.S. 427) has a portion of the outer lip broken away, giving it the appearance of being internally smooth. An examination of numerous excellently preserved topotypes has shown the inner edge of the outer lip to be distinctly denticulate, bearing about 15 small teeth.

This form differs from *Marginella* s. s. [genotype species, *Voluta glabella* Linné (1758, p. 730)], in having five instead of four columellar plaits, and in having a lower spire. It apparently belongs in the group *Cryptospira*, characterized by having five to six plaits and a low spire, but typically without a denticulate outer lip. Several forms from the Eocene of the Paris Basin, which represent the same group as *M. instabilata*, have been placed by Cossmann and Pissarro (1910–1913, pl. 46, fig. 208 bis 1–10) in the section *Gibberula* [Swainson (1840, p. 323, genotype, *G. zonata* Sowerby = *G. oryza* (Lamarck)] under the genus *Cryptospira*. Cossmann's (1899, p. 96) use of *Gibberula* for the five to six plaited forms with denticulate outer lip does not seem justified, the type having neither a denticulated outer lip nor exposed spire.

M. instabilata rather closely resembles *M. multifilosa* Anderson and Hanna (1925, p. 79, pl. 7, figs. 2, 3), from the type Tejon Eocene. The latter species possesses six columellar plaits instead of five. A species of *Marginella* from the Gries Ranch zone on Porter Creek (Loc. A-364) differs from *M. instabilata* in having much less of the spire exposed, a broader reflection of the outer lip and a more quadrate outline; however, this species also has five columellar plaits and a slightly denticulate outer lip. This species is figured for comparison (pl. 47, fig. 12). A single specimen in the University of California Museum from the Lincoln zone of Grays Harbor County, Wash., is somewhat larger than the Gries Ranch species but resembles it in having the same general shape and five columellar plaits. The outer lip has been broken, making it impossible to observe its characters. *M. shepardae* Tegland (1933, p. 127, pl. 10, figs. 22, 23), from the type Blakeley zone of Washington, is larger and more tumid and always has four columellar plications.

Family CANCELLARIIDAE

CANCELLARIA Lamarck, 1799

Genotype, *Voluta reticulata* Linné. Recent, West Indies.

"CANCELLARIA" LANDESI Van Winkle

Cancellaria landesi VAN WINKLE, *1918*, p. 91, pl. 7, fig. 17.
?Nyctilochus sp. DICKERSON, *1917*, p. 160, pl. 31, fig. 5.

The reference of this species to *Cancellaria* is extremely questionable, but the available material is not sufficient to determine its correct generic affinities.

Family CONIDAE

Genus CONUS Linné, 1758

Genotype, *Conus marmoreus* Linné. Recent, Indo-Pacific.

CONUS RUCKMANI Dickerson

Plate 47, figures 27, 28

Conus ruckmani DICKERSON, *1917*, p. 179, pl. 31, figs. 6*a*, 6*b*; VAN WINKLE, *1918*, p. 76.
Conus washingtonensis VAN WINKLE, *1918*, p. 92, pl. 7, fig. 9.

A study of numerous topotype specimens ranging in size from very young to mature shows marked changes in the proportion of spire to body whorl. Extremely young forms are high spired, lack the noded ornamentation on the shoulder, and have a revolving fold immediately below the suture. This is precisely the form described by Van Winkle as *Conus washingtonensis*. The mature form varies in length of the body whorl and may have the shoulder strongly noded, smooth or intermediate. The spiral ribbing of the body whorl is distinct on uneroded specimens but is easily destroyed by wear. The anal notch is relatively shallow as shown by the growth lines, which are moderately pro-

tractive from the suture to the angulation, becoming vertical a short distance below.

This species is very similar to certain varieties of *C. remondii* Gabb (1864, p. 122, 226 (in part), pl. 20, fig. 79; Stewart, 1927, p. 414), from the Tejon Eocene of California, which have the spiral sculpturing extending over the entire surface of the body whorl below the angulation; however, the latter species has a deeper, more convex anal notch; the growth line below the angulation is protractive above and retractive below instead of being almost vertical; the spiral sculpture is finer and the nodes more numerous.

Family TURRIDAE

Genus CLAVATULA Lamarck, 1801

Genotype, *Clavatula coronata* (Chemnitz) Lamarck.

CLAVATULA ARNOLDI (Van Winkle)

Plate 47, figures 24, 26

Hemifusus arnoldi VAN WINKLE, *1918*, p. 89, pl. 7, fig. 11.

The growth lines show the presence of a moderately concave, unsymmetrically rounded anal notch, which lies on the upper surface of the whorl above the angulation, very much as in the typical form. The nuclear whorls are somewhat larger than those of the typical nucleus and are distinctly naticoid, having about two and one-half volutions, which are smooth except for the last one-half turn ornamented by three to four spiral ribs.

Genus SPIROTROPIS Sars, 1878

Genotype, "*Spirotropis carinata* Philippi" Sars.

SPIROTROPIS (SPIROTROPIS) WINLOCKENSIS Effinger, n. sp.

Plate 46, figures 12, 16

Surcula dickersoni (Weaver), DICKERSON, *1917*, p. 161 (twice), pl. 31, figs. 3*a*, 3*b*; VAN WINKLE, *1918*, p. 76 (in part).

Shell small, high-spired; post-nuclear whorls eight, turreted, angle situated slightly below center of exposed portion of whorl; surface above angulation flat or very slightly concave, ornamented by seven revolving threads; angulation fairly sharp, bearing two prominent rounded spiral ribs, one located on the angulation, the other immediately above; surface below the angulation and above the suture tapering inward anteriorly, bearing four strong spiral ribs; surface of body whorl below angulation convex above, concave below, ornamented by 22 to 23 spiral ribs, between which are sometimes developed finer spiral threads; suture linear, distinct; canal moderately long, deeply channeled, twisted very slightly to the left; outer lip thin; inner lip smooth and covered by only a thin callus wash; nuclear whorls two, smooth, the first rather flat and having the appearance of being mounted on the side of a higher second whorl; posterior sinus located medially on surface above the angulation, symmetrical, strongly U-shaped. Dimensions: holotype 33,607, altitude 16.4 mm, maximum diameter 6.5 mm, apical angle 32°.

S. winlockensis closely resembles *S. dickersoni* (Weaver), with which it has been confused. Abundant comparative material from the type locality shows the Lincoln species to have a wide range of variation in the apical angle, character of the angulation, shape of the whorl, and in certain features of the sculpturing. Some of the variants approach the Gries Ranch form in general appearance. The latter, however, shows very little variation and may be distinguished by its sharper angulation, deeper and more symmetrical anal notch, and by the presence of strong spiral ribbing on the upper surface of the whorl.

Genus EXILIA Conrad, 1865

Genotype, *Exilia pergracilis* Conrad.

EXILIA WEAVERI Dickerson

Exilia weaveri DICKERSON, *1917*, p. 173, pl. 30, figs. 1*a*, 1*b*; VAN WINKLE, *1918*, p. 76.

Exilia weaveri appears to be closely related to *E. dickersoni* (Weaver) (1912, pp. 50, 51, pl. 3, fig. 29; pl. 14, fig. 124), a common Cowlitz species, but may be

easily distinguished by its finer ornamentation, especially the axial ribs, by its more convex whorls, and by its deeper posterior sinus as expressed in the growth lines. The Gries Ranch species more closely resembles the exilias from the Cowlitz formation incorrectly figured by Dickerson (1915, pl. 9, figs. 2*a*, 2*b*) as "*E. perkinsiana* (Cooper)," but may be separated by its slightly more convex whorls, more concave growth lines, fewer number of longitudinal and spiral ribs. *E. weaveri* differs much more from *E. lincolnensis* Weaver (1916a, pp. 51, 52, pl. 4, figs. 49, 50), from the Lincoln zone, in lacking the well-developed nodes of the latter and in possessing more rounded whorls, which lack all traces of the anterior and posterior angulation.

Family ACTEONIDAE

Genus ACTEON Montfort, 1810

Genotype, *Voluta tornatilis* Gmelin. Recent, European seas.

ACTEON PARVUM Dickerson
Plate 47, figure 2

Acteon parvum DICKERSON, *1917*, p. 172, pl. 29, figs. 12*a*, 12*b*; VAN WINKLE, *1918*, p. 76.

Acteon parvum is closely related to *A. chehalisensis* (Weaver) (1916a, p. 55, pl. 4, figs. 55, 56), from the Lincoln zone, but may be differentiated by its more tumid body whorl, lower spire, and fewer number of punctate spiral striae.

Family ACTEOCINIDAE

Genus VOLVULELLA Newton, 1891
(=Volvula Adams)

Genotype, *Volvula rostrata* A. Adams. Recent, Australia.

VOLVULELLA TABORI Effinger, n. sp.
Plate 47, figure 11

Shell minute, thin, fusiform, convolute; posterior and medial portion of aperture narrow; anterior portion moderately dilated, slightly flaring below; lower portion of inner lip bearing an inconspicuous fold, which extends to the lower margin of the aperture; umbilicus represented by a small fissure; sculpturing consisting of minute, incised, spiral lines, which are more prominently developed on the lower half of the body whorl. Dimensions: holotype 33,612, altitude 2.7 mm, maximum diameter 1.1 mm.

This appears to be the oldest recorded occurrence of *Volvulella* on the Pacific Coast. It is known also from the Eocene of eastern North America and Europe.

Family SCAPHANDRIDAE

Genus SCAPHANDER Montfort, 1810

Genotype, *Bulla lignaria* Linné. Recent, European seas.

SCAPHANDER WASHINGTONENSIS Weaver
sub-sp. GOODSPEEDI Effinger, n. sub-sp.
Plate 47, figures 14, 15

Shell small, thin, ovate in outline; posterior end truncate, narrow, imperforate; aperture narrow posteriorly, greatly expanded anteriorly; lower portion of inner lip covered by a narrow rounded rim of callus, disappearing beneath the parietal wall, which lacks any noticeable deposit of callus; outer lip simple, slightly attenuate posteriorly; ornamentation consisting of about 30 to 35 deeply incised narrow spiral striae which alternate with broad flat-topped ridges, varying in width from twice that of the striation on the anterior and posterior ends to three or four times on the medial portion of body whorl. Dimensions: holotype 33,611, altitude 4.2 mm, maximum diameter 2.3 mm.

S. washingtonensis sub-sp. *goodspeedi* differs from *S. washingtonensis* Weaver (1916a, p. 56, pl. 5, fig. 68), from the Lincoln zone, in being slightly more tumid, in that the anterior portion of the aperture is somewhat more expanded, and in that the callus rim of the lower inner lip disappears beneath the parietal wall, which lacks all traces of the callus.

Genus CYLICHNINA Monterosato, 1884

Genotype, "*Bulla*" *umbilicata* Montagu.

CYLICHNINA TURNERI Effinger, n. sp.
Plate 47, figure 3

Haminea cf. *petrosa* (Conrad), DICKERSON, *1917*, p. 160; VAN WINKLE, *1918*, p. 76.

Shell minute, cylindrically ovate, sides slightly and evenly arcuate; apex sharply truncate, perforate; central portion of aperture narrow, posterior portion slightly dilated, anterior portion moderately dilated; inner lip sloping with moderate convexity from apex to one-fourth the length from anterior end, slope breaking where free portion of inner lip joins parietal wall; anterior portion of aperture abruptly and evenly rounded; columella bearing an inconspicuous fold, above which is a distinct umbilical groove; umbilicus partly open; sculpture consisting of many fine spiral striae rather uniformly distributed over external surface of shell, alternating with broad, flat-topped areas. Dimensions: holotype 33,619, altitude 3.2 mm, maximum diameter 1.5 mm. Named in honor of Earl Turner of Texas College of Agriculture and Mines.

C. turneri is similar to *C. tantilla* (Anderson and Hanna) (1925, pp. 140, 141, pl. 7, figs. 4, 8, 9, type Tejon Eocene, California) but differs in having a well-defined umbilical groove, a more marked break in slope in the inner lip at the lower parietal margin, and in lacking the heavy deposit of callus on the inner lip.

Phylum COELENTERATA
Class ANTHOZOA

BALANOPHYLLIA cf. VARIABILIS Nomland

Plate 47, figure 20

Balanophyllia variabilis NOMLAND, *1916*, p. 66, pl. 4, figs. 2, 3, 4, 13.

Several specimens of a small cup coral have been obtained from the conglomeratic sandstone at Gries Ranch, but these are too poorly preserved for precise determination.

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UPPER CRETACEOUS FORAMINIFERA FROM THE NORTHWEST BASIN, WESTERN AUSTRALIA

IRENE CRESPIN

At the time of publication by the Geological Survey of Western Australia of the *Monograph of the Foraminifera and Ostracoda of the Gin Gin Chalk*, by F. Chapman, in 1917, the locality of Gin Gin, about 50 miles north of Perth, was the only known exposure of a Cretaceous chalk in Australia. Recent survey work by geologists of companies engaged in the search for oil has brought to light many new exposures over a fairly extensive area about 600 miles north of Gin Gin, while Upper Cretaceous chalks have been determined in borings around Carnarvon, about 450 miles north of Gin Gin.

The first records of Upper Cretaceous Foraminifera in Australia were made by Prof. Walter Howchin as early as 1893, when he determined several species from borings which were put down for water in central Australia. In 1907, he issued a small paper on the Foraminifera from Gin Gin. It was not until 1917, when F. Chapman re-examined the chalky material from Gin Gin, that a further list of Upper Cretaceous Foraminifera appeared. Several years later, in 1934, beds of Upper Cretaceous age containing a rich foraminiferal assemblage were proved in northwest Australia. The material was collected by D. Dale Condit and E. A. Rudd of Oil Search Ltd., Sydney, and its paleontological examination was carried out by F. Chapman and the present author for the Commonwealth Government in the course of the search for oil in Australia. Many other outcrops have since been located in the Northwest Basin.

This extensive series of Upper Cretaceous beds outcrops at various localities from the head of Exmouth Gulf, south about 100 miles towards Minilya River. About 75 miles still farther south, around Carnarvon, the chalks appear in borings. There is also an exposure near the Murchison River Homestead, about 150 miles south of Carnarvon. These foraminiferal beds are now grouped under the title of "Cardabia series," after the station of that name, close to which are some good outcrops.

The list of Upper Cretaceous Foraminifera determined by F. Chapman from the outcrop at Gin Gin has been considerably augmented by the presence of numerous species from these new localities in Northwest Australia. Many of the species are closely related to the European forms, while some have previously been described only from American Upper Cretaceous rocks.

The lithological characters of the Cardabia series fall into three distinct divisions: (1) Cream-colored limestones; (2) glauconite sands; (3) chalks and marls.

CREAM-COLORED LIMESTONES

Outcrops of this type are found in several localities: Cardabia Station, Weir Paddock on bank of Cardabia Creek, near Korojon Pool; about 5 miles east of Centenary Bore, Cardabia Station, near Mt. Remarkable; hills along track from Cardabia to Cardabia outcamp, 7 miles east of Government well; 3 miles from Remarkable Hill; hill immediately south of the fence, southeast corner of Bullara Station; hill, 1.5 miles north of Giralia to Bullara Track on west flank of Giralia anticline; low rise, 1 mile north of Giralia-Bullara track, near first foothills, east flank of Giralia anticline; near road, 13 miles south of Wooramel River, toward Geraldton.

These limestones contain numerous

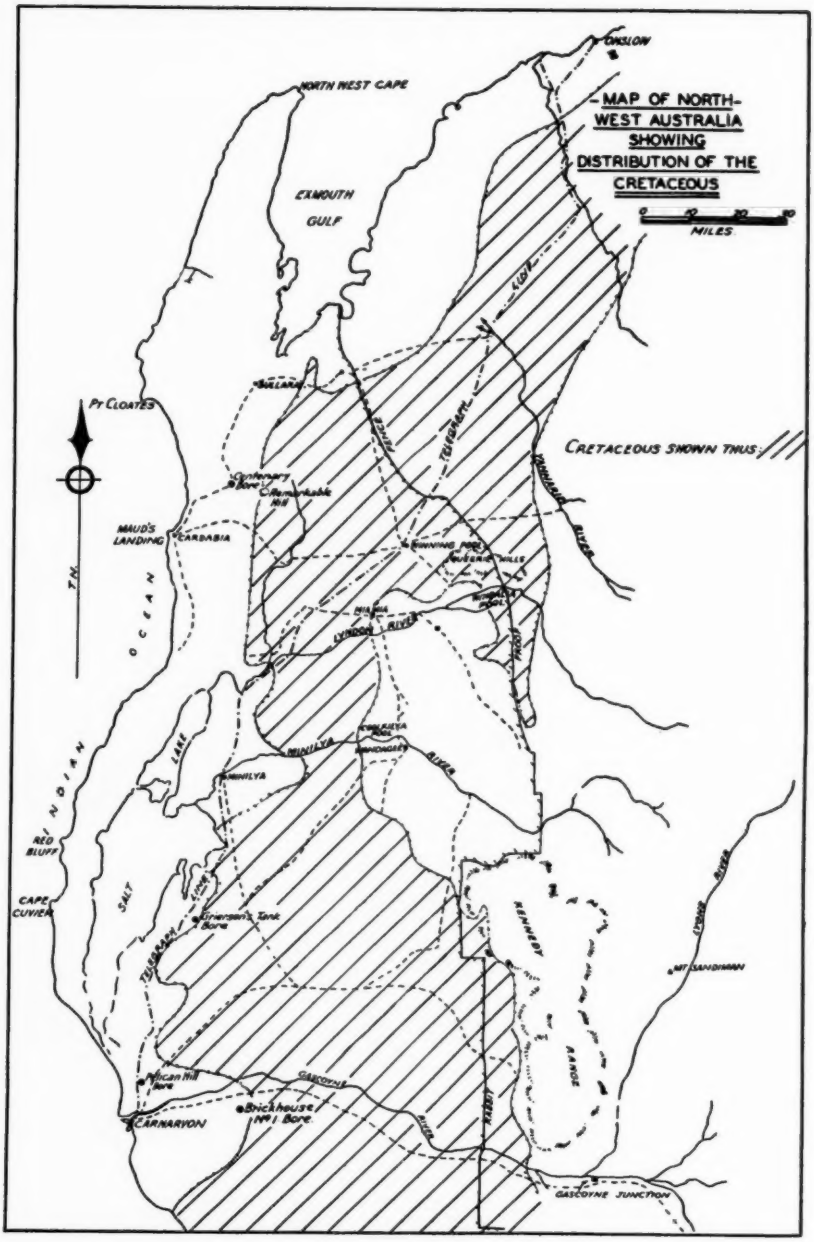
ONSLOW
NORTH WEST CAPE
MAP OF NORTH-WEST AUSTRALIA SHOWING DISTRIBUTION OF THE CRETACEOUS
0 10 20 30
MILES
EXMOUTH GULF
Pr CLOATES
MAUD'S LANDING
CARDABIA
T.N.
OCEAN
INDIAN
RED BLUFF
CAPE CUVIER
SALT
LAKE
MINILYA
LYNDON RIVER
CRETACEOUS SHOWN THUS:
CARNARVON
GASCOYNE JUNCTION
MT SANDIMAN

FIG. 1

Foraminifera, which are found in association with Ostracoda and abundant prisms of *Inoceramus* shell, the presence of which is a feature of the sediments throughout the Cardabia series. In the following list (c) indicates common.

TYPICAL FORAMINIFERA FROM THE CREAM-COLORED LIMESTONES

Spiroplectoides spectabilis (c)
Spiroplectoides clotho (c)
Dorothia bulletta (c)
Marssonella oxycona (c)
Marssonella trochoides
Gaudryina cf. *spissa* (c)
Gaudryina gradata
Spiroplectammina anceps
Verneuilina polystropha (c)
Arenobulimina presli
Arenobulimina puschi
Guembelina globulosa (c)
Ventrilabrella carseyae
Bolivinita decorata (c)
Nodosarella cf. *barroisi*
Pleurostomella clavata
Pleurostomella obtusa
Nodosaria concinna
Dentalina soluta
Dentalina consobrina
Dentalina consobrina var. *emaciata*
Dentalina annulata (c)
Vaginulina legumen
Eouvigerina gracilis
Lenticulina circumcidanea
Lenticulina grata
Lenticulina gaultina (c)
Lenticulina cf. *sternalis*
Lenticulina rotulata (c)
Lenticulina diademata (c)
Lenticulina cf. *nuda*
Lenticulina turgidula
Lenticulina macrodiscus
Lenticulina subalata
Saracenaria acutauriculus
Saracenaria navicula
Marginulina glabra
Frondicularia decheni
Frondicularia cordai
Frondicularia verneuiliana
Frondicularia cf. *frankei*
Flabellina reticulata
Vitriwebbina laevis
Ramulina globulifera
Globigerina cretacea (c)
Globotruncana canaliculata (c)
Anomalina rubiginosa (c)
Anomalina polyrraphes
Anomalina cf. *falcata* (c)
Cibicides lobatulus (c)
Gyroidina nitida (c)
Planulina wuellerstorfi
Globorotalia micheliniana
Rotalia cf. *beccariformis* var.

GLAUCONITIC SAND

The glauconitic sands, which can be traced for a distance of 50 miles, have been examined from three localities: Small creek at 20 mile peg, southeast corner of Bullara station; bed of creek extreme southeast corner of Bullara station; northwest side of Remarkable Hill. This bed contains abundant Foraminifera, many as glauconitic casts, Ostracoda, and ammonites. Prisms of *Inoceramus* shell are also common.

TYPICAL FORAMINIFERA FROM THE GLAUCONITIC SAND

Haplophragmoides latidorsatum
Haplophragmoides cf. *rugosa*
Spiroplectammina anceps
Spiroplectoides sp.
Dorothia bulletta
Gaudryina rugosa
Gaudryina cf. *spissa*
Gaudryina subrotundata
Marssonella oxycona
Clavulina angularis
Clavulina parisiensis
Clavulina amorpha
Guembelina globulosa
Guembelina globifera
Bulimina sp.
Bulimina obtusa
Arenobulimina cf. *puschi*
Bolivinita decorata
Bolivina incrassata
Nodosaria aspera
Nodosaria cf. *zippei*
Dentalina adolphina
Dentalina consobrina
Dentalina confluens
Dentalina lorneiana
Dentalina obliqua
Dentalina intermedia
Vaginulina legumen
Vaginulina trilobata
Marginulina ensis
Frondicularia cf. *frankei*
Lenticulina diademata
Lenticulina cultrata
Lenticulina gaultina
Lenticulina subalata
Lenticulina macrodiscus
Lenticulina discrepans
Flabellina sp.
Pseudopolymorphina sp.
Guttulina adherens
Globigerina bulloides
Globigerina cretacea
Globigerina triloba
Globotruncana arca
Globotruncana canaliculata
Anomalina ammonoides

Anomalina polyrraphes
Anomalina pertusa
Anomalina rubiginosa
Cibicides lobatulus
Cibicides ungerianus
Cibicides cf. *falcata*
Rotalia cf. *beccariformis* var.
Eponides sp.
Gyroidina nitida

CHALK ROCK

The chalk rock is found not only in exposures, but also in borings which have been put down for water throughout the area. Outcrops include the following localities: Scarp west of Winning 12 mile Bore; 2.75 miles west of southeast corner Chargoo Paddock, Minilya station; below 29, Wolla Wolla Paddock, Minilya station; Doorawarrah, 7.75 miles west of rabbit proof fence on motor road to Carnarvon; and Murchison House, Murchison River (south of area included in map). The chalk beds appear in the following bores: Carnarvon (Pelican Hill) bore from 280 to 1,050 feet, in Brickhouse bore from 179 feet 3 inches down to 900 feet, in Grierson's Tank bore from 288 down to 1,060 feet.

Foraminifera are very abundant in this white chalk, and are associated with Ostracoda and abundant prisms of *Inoceramus* shells.

TYPICAL FORAMINIFERA FROM THE CHALK OUTCROPS

Massilina alveoliniformis
Cornuspira cretacea
Dorothia bulletta
Marssonella oxycona
Gaudryina rugosa
Arenobulimina presli (c)
Verneuilina polystropha (c)
Gaudryinella sp. (c)
Spiroplectoides clotho
Reussella spinulosa
Bolivinita eleyi
Bigenerina compressiuscula
Guembelina globulosa (c)
Guembelina globifera (c)
Lagena hispida
Lagena sulcata
Nodosaria concinna
Nodosaria simplex
Nodosaria obscura
Nodosaria prismatica
Dentalina communis
Dentalina consobrina
Dentalina consobrina var. *emaciata*
Dentalina lorneiana
Dentalina pauperata
Siphonodosaria aspera
Marginulina costata
Vaginulina recta
Frondicularia archiaciana
Frondicularia cf. *inversa*
Frondicularia verneuiliana
Frondicularia lanceola
Flabellina rugosa
Lenticulina diademata
Lenticulina gaultina
Lenticulina circumcidanea
Lenticulina discrepans
Lenticulina sternalis
Lenticulina macrodiscus
Saracenaria italica
Saracenaria navicula
Saracenaria ovalis
Globulina lacrima
Ramulina sp.
Globigerina bulloides
Globigerina cretacea
Globigerina voluta
Pullenia quinqueloba
Globotruncana canaliculata (c)
Valvulineria allomorphinoides
Anomalina rudis
Cibicides lobatulus
Gyroidina globosa
Gyroidina nitida
Planulina wuellerstorfi
Eponides sp.

TYPICAL FORAMINIFERA FROM THE CHALK HORIZON IN THE BORINGS

Quinqueloculina venusta
Marssonella oxycona
Marssonella trochoides
Dorothia bulletta
Gaudryina rugosa
Gaudryina stephensoni
Arenobulimina presli
Spiroplectoides spectabilis
Spiroplectoides clotho
Reussella spinulosa
Guembelina globulosa
Bolivina incrassata
Bolivinita eleyi
Bulimina sp.
Pleurostomella subnodosa
Lagena aspera
Lagena globosa
Lagena hexagona
Lagena marginata
Nodosaria raphanistrum
Nodosaria concinna
Nodosaria oligostegia
Nodosaria vertebralis
Dentalina consobrina
Dentalina pauperata
Dentalina megapolitana
Vaginulina legumen
Marginulina glabra

Marginulina schloenbachi
Marginulina munieri
Siphonodosaria aspera
Frondicularia inversa
Frondicularia peregrina
Flabellina elliptica
Lenticulina macrodiscus
Lenticulina ingenua
Lenticulina sternalis
Lenticulina subalata
Lenticulina gaultina
Lenticulina reniformis
Saracenaria navicula
Saracenaria acutauricula
Saracenaria triangularis
Guttulina problema
Globulina subsphaerica
Ramulina aculeata
Globigerina cretacea
Globigerina bulloides
Globigerina acquilateralis
Globotruncana canaliculata
Anomalina rubiginosa
Anomalina nonionoides
Anomalina involuta
Anomalina falcata
Cibicides ungerianus
Rotalia cf. *beccariformis* var.
Planulina wuellerstorfi
Gyroidina globosa
Gyroidina nitida
Globorotalia micheliniana

Equivalents of the Upper Cretaceous horizons of Europe have been suggested for the Northwest Australian occurrences. The glauconite sands, which have been definitely proved to overlie the chalks, are considered to be representative of the Santonian, while the chalks are probably equivalent to the Turonian. It is quite possible that the complete Upper Cretaceous series from Cenomian up to Campanian is represented in the area.

The map attached to this note shows the Cretaceous boundary in the Northwest Basin. The Lower Cretaceous is well developed in the area and is represented by radiolarian cherts and chalky rocks, while in the various borings Foraminifera are associated with the Radiolaria. The type locality for the radiolarian cherty rocks is Winning station, the series, which is very extensive, being now recognized as the "Winning Series." I am indebted to H. R. Raggatt of the Mines Department of New South Wales for permission to use his map which accompanied his paper on the Geology of Northwest Basin, Western Australia, a work which is based on a detailed survey of the area, which he carried out for Oil Search Ltd., Sydney.

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IRENE CRESPIN, DEPARTMENT OF THE INTERIOR, CANBERRA, AUSTRALIA. MANUSCRIPT RECEIVED BY THE EDITOR, JULY 15, 1937.

PALEONTOLOGICAL NOTES

A PERMIAN EURYPTERID FROM OKLAHOMA

C. E. DECKER

ABSTRACT

A well-preserved cephalothorax of an eurypterid was discovered in Lower Permian rocks near Red Rock, Okla. It was found in a light-gray, rather fine-grained sandstone with a number of ferns and other types of plants. This is the first Permian eurypterid reported from North America, and the only other Permian eurypterid described was found in Portugal.

The eurypterid illustrated in Figure 1 was discovered by me several years ago while collecting a fossil flora from Lower Permian beds near Red Rock, Okla. Because it represents one of the last survivors of this interesting group of the Arthropoda, which became extremely rare by Permian time, it is thought that it should be described and illustrated.

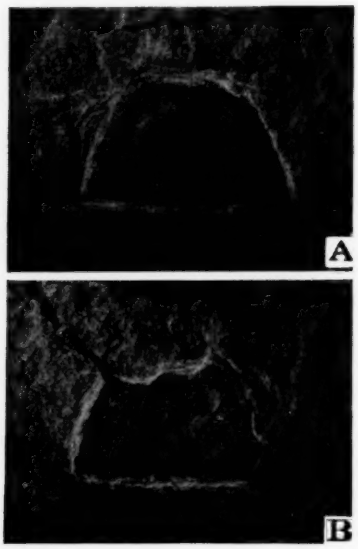

FIG. 1. *A*, Cephalothorax of *Eurypterus oklahomensis* Decker, n. sp., natural size. *B*, Natural mold of upper surface of cephalothorax shown in *A*.

Only the cephalothorax was secured, but the dorsal surface of this part is complete (Fig. 1*A*). The front part of the mold of this surface was broken off and lost when the specimen was collected (Fig. 1*B*). The surface shows a somewhat undulating condition due to compression, yet the surface is slightly convex.

Genus EURYPTERUS DeKay, 1825
EURYPTERUS OKLAHOMENSIS Decker, n. sp.
Text figures 1*A*, *B*

The carapace approaches a semicircular form with the anterior part somewhat flattened. The length of the carapace is 17 mm, and the width at the posterior edge is 27.5 mm, while the anterior width is 17 mm, the latter being the same as the length. At the anterior edge, a very narrow flat extension represents the narrow marginal doubulare. The compound eyes are prominent and kidney-shaped. The slight inside concavity is preserved better on the left than on the right one. The eyes measure 4 mm long and 2 mm wide, and they are placed well forward. There is a distance of 4.25 mm from the front of the eye to the anterior margin, and 7.75 mm from the rear of the eye to the posterior margin. The eyes are 9 mm apart at the rear and 7 mm apart at the front. The ocellar tumescence or mound is slightly back of a line connecting the rear of the compound eyes. The depression made by the tumescence shows well in the mold of the carapace in Figure 1B. Also, the slight depression in front of the tumescence shows as a low ridge on the mold. The compound eyes and ocellar tumescence are on a slightly elevated subquadrangular, glabella-like elevation which simulates the short, low glabella of a trilobite.

Remarks.—This new species approaches most closely the size and form of *Eurypterus microphthalmus*, from the Manlius limestone

(Silurian) of New York, illustrated and described by Clarke and Ruedemann (1912), though it is not nearly so semicircular as this Silurian form, and it is a little wide as compared to its length. Anteriorly it approaches closely the shape of a young individual of *Eurypterus lacustris* Harlan, another Silurian form, although it widens more toward the posterior angles than the latter. However, these differences are of such a minor nature that they raise no question in regard to the assignment of this new form to the genus *Eurypterus*. It is remarkable that this very late form from the lower part of the Permian resembles so closely the Silurian species. A number of eurypterids have been found in Pennsylvanian (Coal Measures) strata of North America, and beds of corresponding age in Europe and elsewhere. In the concretions at Mazon Creek, Grundy County, Ill., *Eurypterus mazonensis* was discovered. It shows the under side of the cephalothorax, the abdominal segments, and four appendages. It was illustrated and described by Meek and Worthen (1868). Outside of Illinois, eurypterids have been reported from Pennsylvanian rocks in Pennsylvania by C. E. Hall (1877) and James Hall (1884). Salter (1863) has described eurypterids from the Coal Measures of Nova Scotia, England, and Scotland.

Occurrence.—Wellington formation, Lower Permian, about 1 mile southeast of Red Rock, Okla. This Oklahoma form constitutes the only Permian eurypterid known from North America, and the second one known from any country. The only other form that is known to occur as late as the Permian was discovered in Portugal and was reported by DeLima (1890).

Types.—Holotype, Univ. Oklahoma, Mus. Paleontology, no. A 16,301; mold of holotype, no. A 16,302.

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THE PREPARATION OF ORIENTED THIN SECTIONS AND A METHOD OF CLEANING SMALL FOSSILS

ANDREW H. McNAIR

The following method has been used successfully to make oriented thin sections of small fragments of bryozoans. It is believed that this method can also be used in sectioning other kinds of micro-fossils, crystals, oolites, or small objects that are difficult to orient.

A small quantity of plaster of Paris is mixed with water until the plaster has the consistency of stiff cake dough. The plaster is placed in a small cardboard box that has been waxed to permit the removal of the hardened plaster block. The surface of the soft plaster is smoothed and the box placed under a binocular microscope. The specimens selected for sectioning are then embedded in the surface of the plaster by the use of forceps

or a needle. Care is taken that the specimens are embedded in exactly the plane in which the section is desired. The specimens are not completely embedded, enough surface being left above the plaster to allow for observation. Three or four specimens of the same species can be embedded in various planes in a space small enough to be enclosed by a microscope cover glass. It is possible to mount four or five groups of specimens in the plaster contained in a small box. After the plaster has set, the block is removed from the box, the groups of specimens cut apart with a scalpel or a razor blade and the excess plaster removed from the sides and back of each small block.

After the plaster blocks have hardened completely they are immersed in Bakelite that has been thinned with the "thinner" supplied by the Bakelite Corporation of Chicago, Ill. A half hour is sufficient to allow complete penetration. The blocks are removed from the solution, dried a short while, then reimmersed. They are then placed on a hot plate and the Bakelite which has soaked into the blocks is allowed to polymerize.

Bakelite has the disadvantages of having a high index of refraction and of staining the edges of the specimens. To obviate these difficulties a very thin solution of celluloid in acetone has been used instead of Bakelite. This does not furnish as hard a block as Bakelite but the cement dries much faster and is transparent.

The face of the hardened block containing the specimens is then ground on a glass plate coated with water and fine carborundum until the required surfaces are shown. The block is observed with a binocular microscope several times during this procedure and the specimens are ground until the desired structures can be seen.

The block is then cemented to a microscope slide with Canada balsam and the reverse side ground until the sections attain the proper thinness.

* * *

Micro-fossils, because of their small size, cannot be cleaned by mechanical methods with any great satisfaction. The following method has been used on certain specimens that are filled with a clayey matrix. The specimens are first soaked in water and are then placed on a watch glass. Small pellets of potassium hydroxide are placed on the specimens and a drop of water added to the pellets. After five to ten minutes the potassium hydroxide is removed, the specimens are placed on a fine screen, face side up, and then sprayed with a strong jet of water.

To furnish the jet an ordinary mineralogical blow-pipe with a fine, almost perfect nozzle was connected to the water supply by means of heavy rubber tubing and a faucet adapter. The joints in the rubber were secured with wire.

Considerable pressure should be used in this apparatus. It is advisable to have a short length of tubing in the system that is less strong than the rest. This will increase in size under excessive pressure, thus allowing for fluctuations in pressure in the water supply, and furnish an indication of the amount of pressure the apparatus will use without bursting.

The jet of water furnished in this manner is capable of removing considerable amounts of shale from the most delicate specimens. Some types of matrix can be removed completely without using caustic potash. The force of water from an ordinary faucet is not capable of removing softened shale from depressions in the surface of specimens. The success of the method depends on the ability of the potash to soften the shale. Specimens having a limestone matrix do not respond to this treatment.

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REVIEW

PLUMMER, F. B., and SCOTT, GAYLE, *Upper Paleozoic Ammonites in Texas;* Texas Univ. Bull. 3701, pp. 1–515, 88 text figs. and 41 pls. Austin, Texas, Jan. 1, 1937.

The appearance of this important monograph, devoted to the Late Paleozoic ammonites of Texas, has been awaited impatiently by many American paleontologists. The volume certainly is not disappointing; it contains descriptions of 28 families (10 new), 70 genera (13 new), and 139 species (54 new). It introduces many changes in the classification of these fossils and advances greatly their usefulness in the intercontinental correlation of the Late Paleozoic rocks. The exact stratigraphic position of each species is given, and detailed comparison with related forms from other parts of North America and foreign lands is included. Both descriptions and illustrations are excellent, and the volume is a great tribute both to the authors and to the Texas Bureau of Economic Geology, under the direction of E. H. Sellards.

The contributions to the knowledge of the Late Paleozoic ammonites made by the authors are so numerous that it is difficult to enumerate them all in a short review. The work of previous students of the Texas and related ammonites, especially that of Hyatt, Smith and Böse, is carefully analyzed and most of their types re-examined. Outstanding in their importance are the conclusions that *Neoicoceras* is an ammonoid and not a nautiloid; *Prouddenites* is not a direct ancestor of *Uddenites; Medlicottia* did not ascend directly from *Artinskia;* and the Russian *Proshumardites* is not an ancestor of the American *Shumardites.* At the same time the authors describe a new Texas genus, *Preshumardites,* a true ancestor of *Shumardites.* It is unfortunate that *Preshumardites* does not sound sufficiently distinct from *Proshumardites,* which in spite of the misleading name remains a genus in good standing.

An excellent discussion of triangular coiling in some Paleozoic ammonites is incorporated on pages 212–215. Much attention is given to the difficult clan of Gastrioceratidae. The modern breaking-up of the old genus *Gastrioceras* into numerous genera and subgenera, in which delicate task Plummer and Scott now take part, may well be compared, in its biologic and stratigraphic importance, with the breaking-up of the still older genus *Productus* of the brachiopods. Tchernov, Girty, Bisat, Wedekind, A. K. Miller, and Ružencer contributed to this task, the work of Bisat being most penetrating and exhaustive. Of the three main features whose evolution Bisat analyzed in the Gastrioceratidae, Plummer and Scott follow two: the shape of the conch and the construction of the suture. The evolution of mouth outline, to which Bisat, and before him Tchernov, paid considerable attention, is not considered by these authors. On the other hand, they use persistently the additional (fourth) feature of Bisat's analysis, the sculpture of the shell, as very fundamental in generic and even family differentiation of the Paleozoic ammonites.

Because the separation of the genus *Paragastrioceras* by Tchernov, solely on the characteristic mouth outline, remained unknown to Böse, J. P. Smith, Schmidt, and now apparently to Plummer and Scott, they have arrived at a different interpretation of the genus than originally designated by Tchernov and since followed by all Russian authors. This unfortunate misunderstanding happened because of the obscure way in which the genus was introduced, but nevertheless the name *Paragastrioceras* can be used only in its original sense, and cannot be transferred to shells which lack the very essential feature of *Paragastrioceras:* the forward bow of the mouth outline (also of the growth lines and constrictions) at the venter.

Plummer and Scott have greatly altered the phylogenetic classification of

the Paleozoic ammonites, and their grouping of these forms in clans and families is a decided improvement on previous classifications. A few of their groupings they themselves wisely consider doubtful and tentative, subject to change with further information. Outstandingly convincing among their groupings are the beautiful reconstructions of step-by-step evolution of the *Shumardites-Perrinites* and *Pintoceras-Metaschistoceras* groups.

No detailed account of the phylogeny of any single species of the numerous ammonites described is given, but perhaps it is just as well that such minute phylogenetic studies as, for instance, those given by Karpinsky for *Medlicottia* or by Smith for *Glyphioceras*, are left for special publications. But since the authors put so much emphasis on the phylogenetic classification of the ammonites studied, they create in the reader's mind an expectation that detailed phylogenetic studies of at least a few of their species have been undertaken.

As a minor technical point, which, however, is of some importance to the reader, I wish to express the desirability of referring illustrated sutures to the diameter (or radius) at which they were observed; a mere indication of scale does not allow an exact conclusion as to the diameter of the coil to which it belongs. With the increasing use of the Paleozoic ammonites for exact correlation, it becomes increasingly important to draw their sutures with as great precision as possible. The smooth-surfaced Paleozoic goniatites provide good surfaces for the exact drafting of their sutures and for their reference to the exact diameter or radius, except when these shells are mechanically distorted. Crude drafting and attempts to generalize have spoiled good illustrations of otherwise excellent monographs in the past. Fortunately the sutures drawn in this monograph are fine, but I wish to remark that the ventral saddle of *Goniloboceras welleri*, shown in figures 2, 4 and 5 of Plate 34, is undoubtedly taken from a weathered specimen. All good specimens in the University of Kansas collection, as well as the types of this species at Stanford University, show that the ventral part of the suture of *G. welleri* is of exactly the same design as that of *G. goniolobum*, that it is bottleneck-shaped at the apex, with two sharp dents.

Considerable misconception was originally introduced in the details of the description and illustration of *G. welleri*, and Plummer and Scott have corrected only part of it.

The use of ammonites for distant correlation of marine Late Paleozoic rocks is described by the authors in an admirably clear way and deserves to be quoted verbatim. The method is called "Correlation of zones by means of ammonite assemblages." The term "zone" in this use apparently indicates an arbitrary column of rocks, of which the observed ammonite assemblage is considered typical.

> The correlation of strata by closely related or identical ammonite assemblages is better, obviously, than correlation by single individuals of uncertain range. A number of assemblages of ammonites that occur in Texas are found in strata widely separated geographically. . . . The presence of the same assemblage of ammonites at a locality in another state or country, *no matter how far removed*, is regarded as evidence that the strata containing the fossils are *approximately* the same age. An error in range of a single ammonite or an error in specific identity of a form with another of closely similar characters yet belonging perhaps to a different phylogenetic branch is likely to be minimized, when a number of species are being considered. (Pp. 379–380, italics by the reviewer.)

These general statements are quite acceptable and they contain in themselves, as well as in the examples quoted by the authors, an idea of the magnitude of possible error in correlation by this method, which is important for its comparison with other methods of correlation.

Because in each succeeding "zone" of

the authors only one ammonite assemblage is recognized (or recorded), the exact horizon at which such an assemblage, or a very similar one, is found elsewhere in the world may indicate any position within the authors' zone. But because the conception of an ammonite assemblage is somewhat arbitrary, and because it is logical to assume that one assemblage, through gradual change, eventually merges with another with the passing of geologic time, we may conclude that the possibility of an accidental off-set matching of the assemblages of two different regions may amount to a stratigraphic (vertical) error, certainly not exceeding the height of one "zone" of the authors, and probably not greater than one-half of it. An idea as to how big the "zones" are may be gathered from the fact that four distinct assemblages are recognized in the Pennsylvanian and four in the Permian of Texas.

M. K. ELIAS, Socony-Vacuum Oil Co. de Colombia, c/o Osorio Hermanos, Aguas Claras, Puerto Wilches, Santander, Colombia, S. A.

SOCIETY RECORDS AND ACTIVITIES

SUMMARIZED MINUTES OF THE TWELFTH ANNUAL MEETING OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The twelfth annual meeting of the Society of Economic Paleontologists and Mineralogists was held in the Tip Top Inn of the Roosevelt Hotel, New Orleans, La., Thursday and Friday, March 17 and 18, 1938. The meeting was held in conjunction with the regular annual convention of the American Association of Petroleum Geologists.

Before the meeting, the Executive Council of the Society held several meetings which were attended by Dr. John B. Reeside, Jr., representing the Paleontological Society. The Council first considered changes in the Society's constitution and by-laws, made necessary by the shift of the Society's business headquarters to the American Association of Petroleum Geologists' headquarters at Tulsa, Okla. A new draft of certain portions of the constitution and by-laws was drawn up, approved by the Council and submitted to the Executive Committee.

The Society's financial affairs were thoroughly discussed and it was decided to modify certain portions of the agreement which the Society of Economic Paleontologists and Mineralogists have with the Paleontological Society. The new agreements are as follows:

The Council of the Society of Economic Paleontologists and Mineralogists meeting with Dr. J. B. Reeside, Jr., representative of the Paleontological Society, on March 17, 1938, in the Roosevelt Hotel, New Orleans, La., reached the following agreement in regard to the continued joint publication of the *Journal of Paleontology:*

1. An unlooked for result has been a falling off in members of the Society of Economic Paleontologists and Mineralogists and in number of subscribers to the *Journal*,—therefore, the contribution of $400.00 by the Society of Economic Paleontologists and Mineralogists to the Paleontological Society in 1936 shall be accepted as equalizing any indebtedness of the Society of Economic Paleontologists and Mineralogists to the Paleontological Society for advertising income or income from non-member subscribers arising out of past joint operation of the *Journal* prior to January 1, 1938.

2. The Society of Economic Paleontologists and Mineralogists agrees to continue as business manager of the *Journal of Paleontology* and further agrees not to make any

direct charge to the Paleontological Society for such management during 1938 except in regard to paragraphs 3, 4, and 5.

3. Surplus stocks of the *Journal* to be reduced by offering two hundred (200) copies of volumes 2 to 11, inclusive, to members and subscribers at three dollars ($3.00) per volume and single numbers of broken volumes at twenty-five cents ($0.25) each. The proceeds of volumes 9, 10 and 11 to be divided between the societies on the basis of sixty per cent (60%) to the Society of Economic Paleontologists and Mineralogists and forty per cent (40%) to the Paleontological Society, the entire proceeds of volumes 2 to 8 to go to the Society of Economic Paleontologists and Mineralogists.

4. The revenue derived from new advertisers,—that is from firms not previously advertisers in the *Journal of Paleontology*,—to be divided between the two societies on the basis of sixty per cent (60%) to the Society of Economic Paleontologists and Mineralogists and forty per cent (40%) to the Paleontological Society.

5. Starting with January 1, 1938, the revenue from non-member subscribers above three hundred (300) in number shall be divided between the two societies on the basis of sixty per cent (60%) to the Society of Economic Paleontologists and Mineralogists and forty per cent (40%) to the Paleontological Society, all income derived from such subscribers up to and including 300 to go entirely to the Society of Economic Paleontologists and Mineralogists.

6. The Paleontological Society Council agrees to take up with and recommend to its membership that Paleontological Society dues be increased from the present five dollars ($5.00) rate to a six dollars ($6.00) annual rate in order to equalize the dues of the two societies

7. The Paleontological Society Council agrees to recommend to the Paleontological Society membership inclusion in the by-laws of authority to collect one dollar ($1.00) annual dues from members of both societies who receive their copy of the *Journal* through the Society of Economic Paleontologists and Mineralogists by payment to the society of Economic Paleontologists and Mineralogists of six dollars ($6.00), a converse arrangement having already been passed and included in the Society of Economic Paleontologists and Mineralogists by-laws.

Signed

For S.E.P.M. STANLEY G. WISSLER
For P.S. JOHN B. REESIDE, JR.

Present at meeting: Sellards, Howe, Israelsky, Moore, Twenhofel, and Rolshausen. Absent: P. P. Goudkoff.

The Council approved payment of the following bill for services rendered by the A.A.P.G. in establishing the business office at Tulsa, and ordered the Secretary-Treasurer to make payment.

Miss Cassidy's full salary, Sept.-March	$700.00
Steel filing cabinet	71.10
Steel shelf stacks	130.35
Expression office records from Fort Worth	2.81
	$904.26

The regular program of the Society began at 1:30 P.M., Thursday, March 17, and the following papers were presented to a good attendance:

M. P. WHITE, A Common Language.

BROOKS F. ELLIS, A Catalogue of Foraminifera.

R. DANA RUSSELL and LEO W. HOUGH, A Test of Petrographic Correlation of Oil Sands in the Gulf Coast.

M. E. UPSON, Pre-Pennsylvanian Stratigraphy and Microfauna of the Deep Wells of West Texas.

CHARLES E. DECKER, Preliminary Paper on *Didymograptus protobifidus* in North America.

The program session was adjourned at 3:30 P.M. and the Society went into the annual business session, President Wissler in the chair.

1. The minutes of the 1937 meeting, published in the *Journal of Paleontology*, were approved.

2. *Report of the Secretary-Treasurer.*—Henry V. Howe, Secretary-Treasurer, expressed his appreciation of the enormous amount of work which had been done for the Society by the preceding

Secretary-Treasurer, Gayle Scott, and recommended that the Resolutions Committee draw up an expression of the Society's appreciation of his services. He then read the following report:

The Secretary-Treasurer was nominated and elected without his permission, and over his protest when he learned of the nomination. A half year spent in Europe attending the International Geological Congress prevented his assuming the duties of the office prior to November. In the interim, the Council authorized the former Secretary-Treasurer to transfer the records of the Society to Tulsa, and an agreement was entered into between the Council and the Executive Committee of the American Association of Petroleum Geologists concerning the handling of the Society's business. The Business Manager of the Association became the Business Manager of the Society. A secretary was employed to devote half time to the Society and half to the Association, salary to be paid equally by both organizations. The arrangement was a happy one and will result in the Society's affairs being placed on a more substantial business basis.

The Secretary-Treasurer on assuming his duties made a trip to Tulsa at his own expense and spent two days with the Business Manager and the Treasurer of the American Association of Petroleum Geologists making an analysis of the Society's financial condition. It was found that for several years the Society had been embarked on too ambitious a publication program and that it had been spending well in excess of its revenues. Cash on hand, as of November first was:

Savings Account	$1,002.36
Checking Account	829.36
Operating Account	125.88
Total	$1,958.11

However, outstanding bills to be paid before the end of the calendar year, or shortly thereafter, existed to a greater amount. These bills, then undetermined as the exact amount, were:

For printing and engraving December *Journal of Paleontology*	$ 743.82
For printing and engraving December *Journal of Sedimentary Petrology*	277.23
For money advanced by American Association of Petroleum Geologists for rent, office equipment and salaries in accordance with agreement between the Society's Council and Association's Executive Committee. (Exact figure to be agreed upon by both bodies at the annual March meeting, estimated by Hull to be)	1,261.66
Total	$2,282.71

It was further found that the Society's membership had dropped considerably from earlier years, and that subscriptions had likewise fallen. The new constitution adopted last year necessitated the printing of new membership and subscription blanks, the cost of which had to be added to the deficit faced by the Society.

This situation was immediately presented to the Council, to the Executive Committee of the American Association of Petroleum Geologists, and to the Treasurer of the Paleontological Society. It was agreed to reduce the *Journal of Paleontology* from eight issues per year to six issues per year (three by each Society) and to reduce the number of copies printed of each issue from 1,500 to 1,300. The number of copies of the *Journal of Sedimentary Petrology* has been reduced from 600 per year to 500 per year. An active campaign was carried on for new members and subscribers, and our advertising revenues have been increased materially.

The Council authorized an audit to be made by Arthur Young & Co., the American Association of Petroleum Geologists' auditors. This audit is made in more detail than previous audits and will be published in the *Bulletin* of the Association. It shows that the Society had made much progress toward solving its financial problems by the end of the year. The form of the 1937 audit differs from that of the 1936 audit but they are easily reconciled. The money owed the American Association of Petroleum Geologists does not appear in the audit; perhaps it should have been included in "Accounts Payable." The method of evaluating the back numbers has been changed to correspond with A.A.P.G. practices. Following is a comparison of the 1936 and 1937 audits:

December 31, 1936				*December 31, 1937*	
Cash					
Demand deposits...	$ 993.62			$2,371.58	
Savings.....	1,685.51			1,007.37	
	$2,679.13	$2,679.13		$3,378.95	$3,378.95
Accounts payable...	$1,296.51			$1,089.86	
Accounts receivable.	686.70			504.25	
Excess payable.....	$ 609.81	—609.81		$ 585.61	—585.61
					$2,793.34
			1938 Dues and Subscriptions.....	$1,486.27	—1,486.27
					$1,307.07
			Owed A.A.P.G.		
			Equipment, etc.....	204.26	
			Salary Cassidy.....	400.00	
				$ 604.26	—604.26
Net Cash Surplus.....		$2,069.32			$ 702.81
		—702.81			
Net Operating loss, 1937.....		$1,366.51			

The above figures need no further explanation. The Society did not end the year 1937 in an insolvent condition, but obviously it could not operate on the same basis very much longer. While the net operating loss in 1936 was $2,115.50 or $748.99 more than the 1937 net operating loss, it is obvious that the curtailment of our publications previously outlined will be necessary for the year 1938. The reason the Society ended the year with an increase of cash was because the Secretary-Treasurer, in accordance with the new constitution, collected dues and subscriptions for 1938 in advance of January first.

It is gratifying to be able to announce that our financial condition has continued to improve since the first of the year as is shown by the following:

MARCH 1 SUPPLEMENT TO CASH AUDIT OF* JANUARY 1, 1938

(* Figures supplied by J. P. D. Hull)

Savings Account (1st Nat'l Bank & Trust Co.).....			$1,007.37
Principal Checking Account (1st Nat'l Bank & Trust Co.).....			2,216.81
Petty Cash Checking Account (Nat'l Bank of Commerce).....			154.77
January 1, 1938, Total Cash in Banks.....			$3,378.95
Deposits (Principal Account) Jan. 1–Mar. 1, 1938.....	$2,172.23		
Checks (Principal Account) Jan. 1–Mar. 1, 1938.....	1,251.32		
		$920.91	
Deposits (Petty Cash Account) Jan. 1–Mar. 1, 1938.....	$ 200.00		
Checks (Petty Cash Account) Jan. 1–Mar. 1, 1938.....	149.26	$ 50.74	
			971.65
March 1, 1938, Total Cash in Banks.....			$4,350.60
First National Bank Savings Account, March 1, 1938.....			$1,007.37
First National Bank Principal Checking Account, March 1, 1938.....			3,137.72
National Bank of Commerce Petty Cash Account, March 1, 1938.....			205.51
March 1, 1938, Total Cash in Banks.....			$4,350.60

The following are statistics concerning the publications distributed by the Society during 1937.

PRINTING AND ENGRAVING BILLS FOR 1937

JOURNAL OF PALEONTOLOGY

	Banta Printing Bills	Meriden Engraving Bills (2% Cash Deducted)	Total Printing and Engraving Bills	S.E.P.M. Total Printing and Engraving Bills
Number 1 (January)*	$ 508.84	$ 282.79	$ 791.63	$
Number 2 (March)	531.62	303.56	835.18	835.18
Number 3 (April)				
Number 4 (June)	693.02	209.86	902.88	902.88
Number 5 (July)	618.73	245.35	264.08	
Number 6 (September)	394.91	219.10	614.01	614.01
Number 7 (October)	562.90	455.45	1,018.35	
Number 8 (December)	552.09	191.73	743.82	743.82
Total	$3,862.11	$1,907.84	$5,769.95	$3,095.89

JOURNAL OF SEDIMENTARY PETROLOGY

	Banta Printing Bills
Number 1 (April)	$267.56
Number 2 (August)	304.82
Number 3 (December)	277.23
Total	$849.61

I. JOURNAL OF PALEONTOLOGY Mailing List

1. S.E.P.M. Membership	
(1) Members	188
(2) Associates	55
2. S.E.P.M. Subscribers	318
3. P. S. Membership	348
Total	909

II. JOURNAL OF SEDIMENTARY PETROLOGY Mailing List

1. Members (active and associate)	113
2. Subscribers	227
Total	340

III. Number of pages in *Journal of Paleontology* (1937) (Exclusive of advertising pages and cover) 722

IV. Number of plates in *Journal of Paleontology* (1937) (Meriden Engraving Company) 93

V. Total edition of *Journal of Paleontology* (1937) (1938—1,300) 1,500

VI. Total edition of *Journal of Sedimentary Petrology* (1937) (1938—500) 600

VII. Number of pages in *Journal of Sedimentary Petrology* (1937) (Exclusive of cover) 136

The Audit does not supply exact figures covering the Society's stock of back numbers of the two Journals. The following is the count supplied by the Tulsa office:

BACK NUMBERS, JOURNAL OF PALEONTOLOGY, DECEMBER 31, 1937

	Copies
Volume 2, Number 1 (March, 1928)	459
Volume 2, Number 2 (June, 1928)	551
Volume 2, Number 3 (September, 1928)	472
Volume 2, Number 4 (December, 1928)	489
Volume 3, Number 1 (March, 1929)	381

* Odd numbers paid for by Paleontological Society.

Volume 3, Number 2 (June, 1929)	382
Volume 3, Number 3 (September, 1929)	219
Volume 3, Number 4 (December, 1929)	260
Volume 4, Number 1 (March, 1930)	277
Volume 4, Number 2 (June, 1930)	275
Volume 4, Number 3 (September, 1930)	314
Volume 4, Number 4 (December, 1930)	308
Volume 4, Number 4 (Supplement)	377
Volume 5, Number 1 (March, 1931)	500
Volume 5, Number 2 (June, 1931)	480
Volume 5, Number 3 (September, 1931)	547
Volume 5, Number 4 (December, 1931)	400
Volume 6, Number 1 (March, 1932)	384
Volume 6, Number 2 (June, 1932)	404
Volume 6, Number 3 (September, 1932)	411
Volume 6, Number 4 (December, 1932)	415
Volume 7, Number 1 (March, 1933)	425
Volume 7, Number 2 (June, 1933)	432
Volume 7, Number 3 (September, 1933)	447
Volume 7, Number 4 (December, 1933)	445
Volume 8, Number 1 (March, 1934)	400
Volume 8, Number 2 (June, 1934)	421
Volume 8, Number 3 (September, 1934)	430
Volume 8, Number 4 (December, 1934)	443
Volume 9, Number 1 (January, 1935)	561
Volume 9, Number 2 (March, 1935)	553
Volume 9, Number 3 (April, 1935)	576
Volume 9, Number 4 (June, 1935)	576
Volume 9, Number 5 (July, 1935)	624
Volume 9, Number 6 (September, 1935)	600
Volume 9, Number 7 (October, 1935)	621
Volume 9, Number 8 (December, 1935)	605
Volume 10, Number 1 (January, 1936)	537
Volume 10, Number 2 (March, 1936)	508
Volume 10, Number 3 (April, 1936)	507
Volume 10, Number 4 (June, 1936)	519
Volume 10, Number 5 (July, 1936)	523
Volume 10, Number 6 (September, 1936)	513
Volume 10, Number 7 (October, 1936)	518
Volume 10, Number 8 (December, 1936)	570
Volume 11, Number 1 (January, 1937)	552
Volume 11, Number 2 (March, 1937)	556
Volume 11, Number 3 (April, 1937)	563
Volume 11, Number 4 (June, 1937)	573
Volume 11, Number 5 (July, 1937)	563
Volume 11, Number 6 (September, 1937)	558
Volume 11, Number 7 (October, 1937)	607
Volume 11, Number 8 (December, 1937)	613

BACK NUMBERS, JOURNAL OF SEDIMENTARY PETROLOGY, DECEMBER 31, 1937

	Copies
Volume 1, Number 1 (May, 1931)	206
Volume 1, Number 2 (November, 1931)	302
Volume 2, Number 1 (April, 1932)	384
Volume 2, Number 2 (August, 1932)	350
Volume 2, Number 3 (December, 1932)	366
Volume 3, Number 1 (April, 1933)	405
Volume 3, Number 2 (August, 1933)	352
Volume 3, Number 3 (December, 1933)	393
Volume 4, Number 1 (April, 1934)	267
Volume 4, Number 2 (August, 1934)	277
Volume 4, Number 3 (December, 1934)	340
Volume 5, Number 1 (April, 1935)	394
Volume 5, Number 2 (August, 1935)	556

Volume 5, Number 3 (December, 1935) 199
Volume 6, Number 1 (April, 1936) 244
Volume 6, Number 2 (August, 1936) 260
Volume 6, Number 3 (December, 1936) 264
Volume 7, Number 1 (April, 1937) 238
Volume 7, Number 2 (August, 1937) 266
Volume 7, Number 3 (December, 1937) 263

It should be explained that the Paleontological Society has joint ownership in Volumes 9, 10, 11 of the *Journal of Paleontology*. The count is given in much more detail than previous counts, and differs from them in some respects. The important thing which it shows is that the Society possesses relatively large stocks for the size of its organization. Our excess printing for the past few years has been almost equal to that felt necessary for the A.A.P.G. *Bulletin*. In 1938 this excess will be reduced for the *Journal of Paleontology* by 200 copies and for the *Journal of Sedimentary Petrology* by 100 copies. The secretary has had considerable difficulty in compiling figures covering sales of back numbers, but has prepared a record of the figures published in the annual statements. While the figures are conflicting it would appear that the Society could well afford to offer 200 sets of the *Journal of Paleontology*, Volumes 2 to 11, and 150 sets of the *Journal of Sedimentary Petrology* at reduced prices to its members and subscribers. It is suggested that such an offer be made for a limited time only and that a price of $3.00 per volume for the former and $1.50 per volume for the latter be made to members. Such a sale would not only place the Society's finances on much sounder footing by bringing in possibly as much as $7,500 cash, but would reduce our expenses for storage and insurance. It likely would result in an appreciable increase in membership.

In conclusion the Secretary-Treasurer is gratified to report that the vigorous campaign conducted by the Council for membership has brought gratifying results as shown by the following comparison:

	September, 1937	March, 1938
Active members	180	206
Associates	59	81

The report was accepted unanimously.

3. *Report of the Editor of the Journal of Paleontology.*—Raymond C. Moore, editor, outlined the policies of his office and pointed out the desirability for more papers of an economic nature. It was moved by Doctor Decker to accept the report with appreciation for his efforts in making this the foremost publication in paleontology. This was voted unanimously.

4. *Report of the Editor of the Journal of Sedimentary Petrology.*—W. H. Twenhofel, editor, outlined the policies of editorial procedure and likewise called for economic papers. His report was adopted by a vote of appreciation.

NEW BUSINESS

1. *Changes in the constitution and by-laws* which had been discussed with the Executive Committee of the American Association of Petroleum Geologists and which had been approved by the Council prior to the general meeting, were read by the Secretary-Treasurer. These changes were adopted unanimously.

These changes, under constitutional provision, are being referred to vote of the membership by mail ballot.

2. *Report of the Research Committee.*—Norman Thomas, chairman, read the following report which was accepted.

The Research Committee of The Society of Economic Paleontologists and Mineralogists at its New Orleans meeting unanimously recommends the following to the New Orleans meeting of the Society:

(1) That we encourage economic paleontologists to publish, and that we encourage other paleontologists to publish more of practical value to their economic colleagues. That this be referred to our editor and a committee that he shall select for positive action in this matter.

(2) That close coöperation between our research committee and the research committee of the American Association of Petroleum Geologists be maintained.

(3) That the editors of the *Bulletin of The American Association of Petroleum Geologists*,

the *Journal of Paleontology* and the *Journal of Sedimentary Petrology* be urged to refer all papers not pertaining to their particular fields to the proper editors so that papers be segregated according to petroleum geology, paleontology, and sedimentation into their respective publications.

(4) That the American Museum of Natural History be commended in fostering its project in relation to Foraminifera.

(5) That a copy of this report be sent to the following:

The American Museum of Natural History
The Executive Committee of the American Association of Petroleum Geologists
The Research Committee of the American Association of Petroleum Geologists.

3. *Report of the Resolutions Committee.*—M. P. White, chairman of the Resolutions Committee, read the following resolutions which were adopted.

Be it resolved that we, the members of the Society of Economic Paleontologists and Mineralogists, express our gratitude and appreciation to the local committees, membership in Louisiana and individuals in New Orleans who have contributed so generously of their time and efforts to make such a profitable and enjoyable meeting at New Orleans.

We especially wish to express our appreciation and commendation to Gayle Scott, Texas Christian University, Fort Worth, Texas, for a his untiring efforts, splended service and all-round contributions to the present success of our Society;

To the officers and executive Committee of the American Association of Petroleum Geologists for granting liberally to the financial aid of the Society;

To J. P. D. Hull, Business Manager of the American Association of Petroleum Geologists, for his efforts in successfully carrying on the business of the Society;

To H. V. Howe for his fine service as Secretary for the past year;

To Stanley G. Wissler and F. W. Rolshausen, executive officers, for their efforts in behalf of the Society;

To R. C. Moore and W. H. Twenhofel, who, at much sacrifice of time, have continued their splendid efforts and skill in maintaining the high standard of the *Journal of Paleontology* and the *Journal of Sedimentary Petrology;*

To C. I. Alexander for securing the papers and arranging the program of the technical session.

The Society wishes also to express its appreciation to the Paleontological Society, to its Council and to John B. Reeside, Jr., for their continued coöperation.

4. *Election of Officers.*—President Wissler announced the results of the election of officers as follows: President, E. H. SELLARDS, Vice-President, PAUL P. GOUDKOFF, Secretary-Treasurer, HENRY V. HOWE.

The meeting adjourned until Friday morning when the following papers were given:

R. C. MOORE and F. B. PLUMMER, Upper Carboniferous Crinoids from the Morrow Subseries of Arkansas, Oklahoma, and Texas.

R. W. HARRIS and DON VIEAUX. Ostracoda Common to the Carboniferous of the British Isles and the Pennsylvanian of Oklahoma.

HUGH ELEY, Paleontology of the Big Bend Region of Brewster County, Texas.

J. B. GARRETT, The Hackberry Assemblage—An Interesting Foraminiferal Fauna of Post-Vicksburg Age from Deep Wells in the Gulf Coast.

J. WILLIS STOVALL, Additional Discoveries of *Cotylorhynchus romeri* (read by title).

J. WILLIS STOVALL and WILLIAM MCANULTY, A New Pliocene Fish Deposit in Oklahoma (read by title).

J. WILLIS STOVALL and DON E. SAVAGE, Recent Discoveries of Phytosaurs on the Cimarron River, Union County, New Mexico (read by title).

STANLEY G. WISSLER, The Application of Numerical Abundance and Faunal Assemblage for Subsurface Correlation.